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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION

PART I—NATURAL CHANGES.

BY

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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION.

INTRODUCTION.

In the year 1911 the national pure-food officials conducted an investigation to determine to what extent was the suitability of citrus fruits for human consumption affected by the state of maturity of the fruit. This was necessary on account of the large amounts of immature citrus fruit with which Florida and California were flooding the market. The outcome of this investigation was the F. I. D. No. 133, which condemned the use of immature citrus fruit in the following language:

> "There is evidence to show that the consumption of such immature oranges, especially by children, is apt to be attended by serious disturbances of the digestive system."

Acting upon this decision, restrictive measures were adopted both by state and national authorities against the sale of immature citrus fruit, and against any attempt to conceal such immaturity, by sweating or by misbranding or mislabeling, or in any other form which might deceive the public as to the real quality of the fruit involved.

The carrying out of these measures required a standard by which to judge the maturity of the fruit. Such a standard was first set by Florida as the result of the findings of a commission of experts, appointed for the purpose, which reported that an orange could be regarded as mature when "its chemical analysis would show the percentage by weight of the total sugar, as invert sugar, to be seven times, or more, than the weight of the total acid, as citric acid."

This was modified by the National Bureau of Chemistry, to read as follows:

"All mature oranges shall contain not less than eight parts of total solids to one part of total acid, calculated as citric acid without water of cristalization";

And that—

"All mature grapefruit shall contain not less than seven parts of total solids to one part of total acid calculated as citric acid without water of crystalization."

As a result of the restrictive measures above referred to, two cargoes of grapefruit from Porto Rico were destroyed at the port of New York by the health officers in charge in 1916, for not reaching the required ratio of 7. Our growers protested, and sent a commission to Washington, to present their claims before the competent authorities. They were given a hearing by the Bureau of Chemistry in which arguments were presented by the commission to show that the standard set might not be applicable to Porto Rican fruit, that the fruit here might come to maturity before it reached the stated ratio of 7, and that perhaps it might never come up to this ratio after all. The chief claim, however, was that the fruit here was fully matured before the ratio of 7 was reached.

To decide this point, as well as to gather data that might be useful in cultivating, fertilizing, and handling the fruit, the investigation herein reported was started in 1916 by the former chemist, Mr. W. B. Cady.

In 1917 Mr. Cady resigned, and the writer was appointed as his successor. The problem was immediately submitted to his consideration by the then Director of the Station, Mr. W. V. Tower, with the request that the work begun by Mr. Cady be continued. However, Mr. Cady's plan of investigation was never available to the writer, and all that was found in the records was a mass of data from which to judge the purpose that Mr. Cady undoubtedly had in mind. The above statement it not made in any spirit of criticism but simply as a candid expression of facts unavoideable in a report of this nature which must embody data collected by two different investigators, and in which each one must have his due. From the data at hand the conclusion was reached that the chief aim was to find out whether grapefruits matured before reaching a ratio of 7, and to study the effect of sweating, and storing, on the ratio and sugar content of the juice. Besides, there were data to show that an attempt had been made to gain an

insight into the seasonal changes suffered by the fruit, and to correlate these changes with the kind of soil and fertilizers used. These may not have been exactly the aims sought; but in the absence of a definite statement as to the real purpose of the investigation, that is what the data seem to show.

The data left by Mr. Cady, included the following records:

1. Measurements of the size of the fruit, and thickness of skin, weight of the fruit, skin, and juice, and analyses of the juice of samples taken periodically. The analyses of the juice included determinations of solids in solution, sugar as invert, sucrose, and acid as citric acid. Also notes on the color of the skin.

2. Parallel analyses of fruit stored without sweating and after being sweated, on which all the above data were also taken. Besides, the number of fruits going to rot during storage was ascertained in each case.

3. Notes on the types of soils on which each tree stood, and chemical analyses of each soil.

4. Some notes on the fertilizers used, but not enough to be useful in drawing conclusions.

5. Tables constructed with the data obtained to show correlations between the factors compared.

The method followed by Mr. Cady as evidenced from his notes consisted in having one or two trees set aside in each of a number of plantations, so that he could go around periodically, (usually every 15 days from September to February) and pick samples from each of the trees for his various experiments. Notes were taken on the type of soil on which the trees stood, and soil samples taken from around the base of the trees were analyzed. In a number of instances notes about the fertilizer used were taken.

The writer thought that no conclusions as to the effect of fertilizers could be drawn from data collected in this fashion, where there were so many factors of variation involved and decided to drop that phase of the project referring to fertilizers. Each tree was fertilized differently, planted on different soil, and under different climatological conditions.

The effect of sweating and storing fruit was so clearly shown by Mr. Cady's work that the writer did not think it necessary to conduct any more experiments along this line.

The system of having trees set aside in different plantations and of collecting samples periodically was continued, and the soils were analyzed whenever new trees were chosen. It was also decided to

carry out determinations of the content of nutritive ingredients in the whole fruit, to gain a general idea of the amount of fertilizer removed by an average crop of grapefruit under the conditions of cultivation and types of soils that obtain in this country. By what has been said it will be evident that all data collected from 1916–1917 was the work of Mr. Cady.

AIMS.

With these general ideas in mind, the original plan of investigation, whatever it might have been, was reconstructed to cover the following aims. These aims were of course to be attained with the aid of Mr. Cady's data:

1. To determine whether grapefruit may be considered mature before it reaches a ratio of solids to acid of 7.

2. To determine the time of the year when grapefruit reached a ratio of 7, Mr. Cady's work having demonstrated that grapefruit here did come up to this ratio.

3. To find out whether there was any difference among the different varieties cultivated here in regard to the points noted above.

4. To gain some knowledge as to the proportions of fertilizing ingredients present in the fruit at different stages of its maturation period.

5. To determine the influence of rainfall on the composition of the fruit.

6. To find out the influence, if any, of type of soil on any of the points enumerated.

7. To see whether the soil composition bears any relation to the composition of the fruit, or to its quality.

8. To find out the influence of storing and of sweating the fruit on the ratio, appearance, keeping qualities, weight, proportion of skin and juice to weight of fruit, sugar content of juice, and, in general, upon the quality of the fruit as a whole.

An immense amount of work would be required to arrive at definite conclusions on any of the points enumerated above. With the data at hand to date, many of the questions raised may be considered as definitely settled, while others would require further work, and changes in the method of investigation to complement the data obtained. However, as it is not possible to give for the present more time to this project, all data collected, whether leading to definite conclusions or not, will be here published, so that they may be available to any other investigator on the subject who may have

use for them. This should be taken, then, only as a report of a work which has not been carried to completion.

For clearness in the discussion, this report will be presented in two parts. Part I will deal with the changes undergone by the fruit without any reference to the factors affecting them, and will take up the first four points enumerated. Part II will be devoted to a discussion of the factors, natural and otherwise, affecting the changes discussed in Part I.

PLAN OF THE INVESTIGATION.

As already explained, there were two lines of investigation indicated by Mr. Cady's work, which the author discontinued, namely: the effect of fertilizers, and the effect of sweating and storing on the composition and quality of the fruit. The former, because it was not thought possible to arrive at any conclusions with the data obtained, or obtainable under the circumstances,[1] and the second, because the point was deemed sufficiently proven by the data at hand.

For the work to be done trees were selected in different plantations in the fruit district along the northern coast. The plantation owners, of whom a list is given further on, were liberal enough to part with the crop of the tree or trees selected, and from each tree a sample of ten or twelve fruits was picked every fortnight. These samples were brought to the laboratory and not later than twenty-four hours after, subjected to the tests given below.

The trees were so chosen that both clay and sandy soils were represented. For the season 1917 to 1918 trees of both Marsh's Seedless and Duncan were used, but for the following season, 1918 to 1919, only Duncans were selected, as this variety is by far the most generally planted of all. The triumph variety is very little cultivated.

During the season 1917–1918 the following data were taken on the fruit:

(*a*) Weight of fruit.
(*b*) Size of fruit.
(*c*) Thickness of skin.
(*d*) Weight of skin.
(*e*) Weight of juice extracted.
(*f*) Solids in solution in juice.
(*g*) Acidity in juice expressed as anhydrous citric acid.

[1] No plan for fertilizing the trees systematically was available, but only notes on the fertilizers used by the planters themselves on their respective places. These varied in amount, composition and character, and could not, of course, serve as a basis for any conclusion.

No soil analyses were performed during this season, due to lack of time.

During the season of 1918–1919 the sucrose content, invert sugar, and total sugar as invert, were determined in addition to the tests given above. Besides, observations were made on the color of the fruit, consistency of the juice cells, and taste (whether sweet, tart, or sour) of the juice.

Soil samples from around the trees used this year were analyzed.

On the samples picked during this season, determinations of nitrogen, ash, phosphoric acid and potash were made on the whole fruit.

METHODS.

The data left by Mr. Cady were taken as follows:

The seasonal variations were observed on samples picked biweekly from trees set aside for the purpose, as already explained. The data included all those detailed above, except the nitrogen determinations and the ash analyses.

The method of sampling followed is described by Mr. Cady in his notes as follows:

"Beginning September 22nd, we selected an average Duncan tree in eight different groves, picked twelve fruits from each of these trees at intervals of every two weeks as work at the laboratory would permit. These fruits were brought to the laboratory and analyzed. The groves from which this fruit was taken ranged from a heavy clay to a light sandy soil."

The effect of storing and of sweating was determined by picking 80 fruits from each of five trees every month, dividing these into two lots of 40 each, one lot sweated and the other left in natural condition. Each week 10 fruits of each lot were weighed, measured, as already explained, and analyzed. This is described by Mr. Cady as follows:

"*Changes that take place in holding sweated and unsweated fruit.*—These tests were from five different groves. Eighty fruits were taken from each grove and divided into lots of 40 each. Forty fruits were sweated forty-eight hours at a temperature of from 90 to 95 degrees Fahr. The other 40 were held in the laboratory for analysis. Ten fruits were analyzed each week from the sweated and unsweated lots."

Another method used consisted in picking lots of 150 or 200 fruits and storing the fruit, one-half sweated and the other unsweated. Samples of 10 fruits were analyzed each succeeding week, and all other observations noted made on them.

Samples of soils in which these trees stood were analyzed as well. As no description of the methods used in the analysis and measurement of the fruit employed by Mr. Cady are available a brief account of those used by the writer will be given.

METHODS OF ANALYSIS.

Size.—The size of the fruit has been expressed by the figure indicating the number of fruits packed in a standard box. This was determined by passing the fruit through circular holes, and taking the number corresponding to that through which the fruit would pass fitting closely.

The dimensions and the corresponding numbers were as follows:

Diameter of holes in inches.	Corresponding number indicating size of fruit.
3 15/16	80
4 1/16	72
4 1/4	64
4 7/16	54
4 5/8	46
4 7/8	36

The contrivance for taking these measurements was found in the laboratory, so that it may be taken for granted that it was used by Mr. Cady in taking his measurements.

Thickness of rind.—The fruits were cut across midway between the upper and lower ends through a plane perpendicular to the axis of the fruit.

On one of the halves, and at several places around the circumference, a ruler was laid flat on the plane section, passing through the center, and the diameter, including and excluding the rind, taken. One-half the difference between the two diameters was taken as the thickness of the rind at that particular point. The average of five or six thicknesses thus found was taken as the thickness of the skin of that particular fruit. The average of the thicknesses of all the fruits in the sample was taken as the thickness of rind in the sample.

Proportion of rind and juice.—The per cent rind and juice were found as described under juice analysis.

METHOD OF ANALYSIS.

Juice analysis.—The fruits were peeled, the peeled fruit expressed by hand, and the pulp strained through cheese cloth until

practically all of the juice had been extracted. This operation was always performed by the same person. The fruits were weighed before peeling and expressing, so that by weighing the skins and the juice the proportion of each in the whole fruit was easily calculated. The seeds were then separated from the juice, and the latter submited to the following tests:

Total solids.—A tall cylinder was filled to the brim with the juice, the air bubbles allowed to escape, and a Brix spindle inserted. The temperature was taken, the Brix spindle read, and the reading corrected according to the temperature by means of Spencer's table of corrections, The corrected degree Brix was taken as the per cent solids in solution. From the degree Brix the specific gravity was found in a table of equivalents.

Acidity.—Ten cubic centimeters were measured off by means of a pipette into 150 cc. Erlenmeyer flask, 50 cc. distilled water added, and the whole boiled to expel carbon dioxide. The diluted juice was cooled, phenolphthalein added as indicator, and titrated with caustic soda solution so prepared that one cubic centimeter was equivalent to one-hundredth gram of anhydrous citric acid.

Sucrose.—The double polarization method of Clerget was used. The inversion was accomplished by concentrated hydrochloric acid, acting on the juice at ordinary temperatures for twenty-four hours. Hertzfeld formula and table of corrections for the constant were employed in the calculations.

Invert sugar.—School de Hans Method was used.

Total sugar as invert.—This was calculated from the figures for sucrose and invert sugar.

DETERMINATION OF FERTILIZING INGREDIENTS IN WHOLE FRUIT.

Preparation of the samples.—For this work the whole fruit was quartered, an upper and a lower quarter were peeled and squeezed for the tests already explained and the other two quarters were passed without peeling or pressing through a chopping machine. The fruit was thus converted into a pulp containing skin, juice, seeds, and all. The whole was then weighed, and dried at 80° to 100° C., in a large air oven, and the loss in weight determined. The drying process was continued until the dried residue could be easily ground in a mill to a coarse powder. The powder thus obtained, which resembled ground roasted coffee, was preserved in wide-mouthed glass jars tightly closed. In the samples so prepared, the following determinations were made:

DETERMINATIONS.

Nitrogen.—Nitrogen was determined by the regular Kjeldahl process in 10-gram samples.

Phosphoric anhydride was determined in the ash, by dissolving in agua regia, and following the volumetric method outlined in bulletin 107 of the Bureau of Chemistry, U. S. Department of Agriculture.

Potash.—Potash was determined in the ash according to the following method: A portion of ash corresponding to 5 grams of sample prepared as described above was boiled for one-half hour with 100 cc. to 150 cc. distilled water. The solution obtained was made alkaline with ammonia and treated with ammonium oxalate, without filtering. The solution was made to a volume of 200 cc. passed through a dry filter, and an aliquot of the filtrate taken. The aliquot was evaporated to dryness after the addition of 1:1 sulphuric acid, the residue burned to destroy organic matter and expel ammonia, the white residue taken up with water, and the solution treated with barium chloride to remove sulphates. The precipitate was filtered off, and washed. The filtrate and washings were received in a silica dish, treated with perchloric acid, and evaporated on the water bath until white fumes were given off. The residue was then taken up with 95 per cent alcohol, thoroughly washed with alcohol by decantation, passed through a Gooch crucible, washed again in the crucible, dried at 120–130° C. and weighed. Hot water was passed through the crucible, and then 95 per cent alcohol, the crucible dried once more at 120–130° C., and then weighed again. The difference between the first and second weighings represents the potash as potassium perchlorate. By multiplying the weight of the potassium perchlorate obtained by 0.340, the actual potash was obtained.[1]

Ash.—The ash was obtained by burning the material to whiteness in a muffle furnace, well regulated to avoid loss of alkalis by volatilization.

Moisture.—The moisture in the prepared sample was determined by heating in a flat German-silver dish, to constant weight in an oven at 110° C.

Taking into account the moisture content of the prepared sample and the loss in weight sustained by the sample during the process

[1] This method was followed because it was very hard at the time to secure chloroplatinic acid, which would have been preferred as a precipitant by the writer.

of preparation, the results obtained were calculated back to the whole fruit.

ARRANGEMENT OF DATA.

The data will be presented mostly in tabular form, with occasional graphs based on the tables given. The discussion will be by subjects, taking up each of the points to be proven in succession, and grouping together all the data necessary to make clear the point under discussion. In grouping the data appertaining to each subject, however, they will be presented, as far as possible by seasons. The method of averages has been freely used, but all figures for individual cases are also given, so that the degree of variation may be better appreciated.

Part I.

NATURAL CHANGES.

By the study of these changes, an effort will be made to determine the following points:

1. Whether grapefruit may be considered matured before the ratio of total solids to acids in solution in its juice reaches 7.

2. What is the time of the year when grapefruit reaches the aforesaid ratio of 7 under our conditions.

3. To find out whether there is any difference among the varieties cultivated in this country in regard to the points noted above.

4. To gain some knowledge as to the proportions of fertilizing ingredients present in the fruit at different stages of its maturation period.

SEASONAL CHANGES OF GRAPEFRUIT.

In order to obtain the necessary knowledge to settle the four points at issue in this phase of the investigation, it was found necessary to find out first of all what changes were undergone by the fruit when left on the tree under natural conditions throughout the harvesting season; hence, the biweekly analyses of samples picked from trees selected in different localities representative of the fruit district of the Island. In this study the three varieties of grapefruit almost exclusively planted in this country received separate attention so as to be able to make comparisons between their respective behaviors. The three varieties referred to are the "Triumph" the "Marsh's Seedless" and the "Duncan". Of all, the Duncan is the most popular, followed by the Marsh's Seedless, while the "Triumph" is very little planted.

This work was continued uninterruptedly from September, 1916, to February, 1919; that is, through three consecutive seasons. During the first season, 1916 to 1917 (work conducted by Mr. Cady), the three varieties were studied; during the next season, 1917 to 1918, only the "Marsh's Seedless" and the "Duncan" received attention, the writer being convinced that no more data were neces-

sary to judge the "Triumph," while during the last season, 1918 to 1919, only the "Duncan" variety was used, as enough data were already on hand about the "Marsh's Seedless," and enough information had been accumulated for the purposes of a comparison. Besides, the Duncan being planted almost universally, was chosen exclusively for the tests of this year, to simplify matters.

The results of the analyses, by seasons, varieties, and trees, are given below in tabular form, for each season and each variety separately, with proper comments in each case. Upon the facts thus revealed, conclusions as regards the points enumerated will be drawn in a further discussion of the data.

SEASON 1916 TO 1917.

Trees were selected in different groves, and every fortnight 10 to 12 fruits were picked from each one of the selected trees. The samples so picked were all analyzed in the same day and by the same methods. These trees were set aside by the owners of the groves, and no fruits, except the samples, were picked from them. This gave the investigator the chance to choose his fruits to suit his ideas. In this instance the fruits were chosen so that they would be, as far as possible, from the same bloom.

Following will be found a list of the groves in which trees were selected for the biweekly analyses above referred to, and analyses of the soils on which they stood.

The discussion as to the relations which exist, if any, between kind of soil and composition or behavior of fruit, will be deferred for the present, to the time when this phase of the problem comes under consideration.

Trees Selected for the 1916–17 Work.

Grove	Location of grove	Owner or Manager	Tree (Variety)
A	Pueblo Viejo	Mr. Boyd	Duncan
B	Vega Baja	Mr. M. L. David	Triumph Duncan Marsh's Seedles
D	Pueblo Viejo	Mr. Dunham	Duncan
E	Palo Seco	Mr. Fletcher	Duncan
G	Trujillo Alto	Mr. Lippit	Duncan
I	Bayamón	Mr. Newton	Duncan
J	Bayamón	Mr. Parkhurst	Duncan
K	Pueblo Viejo	Mr. Reed	Triumph
L	Río Piedras	Mr. Scoville	Marsh's Seedles
N	Vega Alta	Mr. E. D. Stevens	Duncan

COMPOSITION OF SOIL IN WHICH EACH TREE STOOD.

Soil samples were taken from around the base of each tree, and analyzed with the following results:

Soil taken from near test grapefruit tree in Grove A, March 1917. "Sandy Loam."

Reaction	Acid.	
Insoluble matter	85.66	per cent.
Iron and alumina	9.70	per cent.
Lime	0.05	per cent.
Magnesia	None.	
Phosphoric acid	0.13	per cent.
Potash	0.100	per cent.
Nitrogen	0.050	per cent.

Soil taken from near test tree "Duncan" in Grove B, near Vega Baja, March 7, 1917. Red clay loam.

Reaction	Acid.	
Insoluble matter	77.45	per cent.
Iron and alumina	13.40	per cent.
Lime	0.35	per cent.
Magnesia	Trace.	
Phosphoric acid	0.191	per cent.
Potash	0.009	per cent.
Nitrogen	0.130	per cent.

Soil taken from near test tree "Marsh's Seedless" in Grove B. Red Sandy Clay.

Reaction	Acid.	
Insoluble matter	81.80	per cent.
Iron and alumina	11.50	per cent.
Lime	0.30	per cent.
Magnesia	Trace.	
Phosphoric acid	0.191	per cent.
Potash	0.0097	per cent.
Nitrogen	0.101	per cent.

Soil taken from near test grapefruit tree in Grove I. "Sandy loam."

Reaction	Acid.	
Insoluble residue	88.21	per cent.
Iron and alumina	5.70	per cent.
Lime	0.20	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	0.039	per cent.
Nitrogen	0.112	per cent.

Soil taken from near test tree in Grove E, March 26, 1917.

Reaction	Acid.	
Insoluble matter	72.51	per cent.
Iron and alumina	12.40	per cent.
Lime	6.40	per cent.
Magnesia	0.47	per cent.
Phosphoric acid	0.606	per cent.
Potash	0.097	per cent.
Nitrogen	0.168	per cent.

Soil taken from near test tree in Grove G, March 18, 1917. Clay soil "very hard."

Reaction	Acid.	
Insoluble residue	62.60	per cent.
Iron and alumina	19.92	per cent.
Lime	0.15	per cent.
Magnesia	Trace.	
Phosphoric acid	0.331	per cent.
Potash	0.174	per cent.
Nitrogen	0.168	per cent.

Soil taken from near test tree in Grove I, near Bayamón, February 9, 1917. "Sandy loam."

Reaction	Acid.	
Insoluble matter	87.49	per cent.
Iron and alumina	6.70	per cent.
Lime	0.10	per cent.
Magnesia	Trace.	
Phosphoric acid	0.35	per cent.
Potash	0.019	per cent.
Nitrogen	0.121	per cent.

Soil taken from near test grapefruit tree in Grove J, near Bayamón, March 7, 1917. "Sandy soil."

Reaction	Acid.	
Insloube matter	90.08	per cent.
Iron and alumina	5.70	per cent.
Lime	0.14	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	None.	
Nitrogen	0.214	per cent.

Soil taken from near annual test tree "Triumph," Grove K, "Reddish clay soil." March 20, 1917.

Reaction	Acid.	
Insoluble residue	65.40	per cent.
Iron and alumina	19.50	per cent.
Lime	0.20	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	Trace.	
Nitrogen	0.168	per cent.

Soil taken from near test tree in Grove L, March 26, 1917. "Sandy Loam."

Reaction	Acid.	
Insoluble residue	87.11	per cent.
Iron and alumina	8.40	per cent.
Lime	0.20	per cent.
Magnesia	None.	
Phosphoric acid	0.191	per cent.
Potash	None.	
Nitrogen	0.112	per cent.

Soil taken from near test grapefruit tree in Grove N, March 7, 1917.

Insoluble residue	87.94	per cent.
Iron and alumina	6.40	per cent.
Lime	0.30	per cent.
Magnesia	Trace.	
Phosphoric acid	0.100	per cent.
Nitrogen	0.097	per cent.
Potash	0.089	per cent.

The analyses of the different samples of fruit are presented below in tabular form for each tree and for each variety.

INDIVIDUAL TREE RECORDS, SEASON 1916–1917.

TABLE 1.

Analyses of Fruit (Duncan) from Test Tree, Grove A, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 3	583	36	G. Y. T.	3/8	31.31	20.988	37.68	8.2	1.28	6.4	2.44	4.89	2.33	1.047
October 6	575	46	G. Y. T.	5/16	30.56	26.450	38.50	7.8	1.39	5.5	2.44	4.65	2.09	1.167
October 23	592	54	G. Y. T.	5/16	31.74	31.968	38.87	8.0	1 26	6.3	2.69	4.40	1.59	1.691
November 3	505	54	G. Y. T.	9/32	26.41	27.270	43.80	8.6	1.25	6.9	3.10	4.16	94	3.297
November 21	490	54	Y. S. G. T.	9/32	25.61	26.460	46.65	8.1	1.34	6.0	3.10	4.89	1.67	1.856
December 11	617	46	Y. G.	3/8	29.83	28.382	41.83	8 2	1.20	6.9	2.69	4.40	1.59	1.691
February 15	541	40	B. Y.	1/4	30.00	21.640	49.92	8.5	1.25	6.8	3.50	4 89	1.27	2.755
February 22	500	54	Y. S. G. T.	1/4	26.66	27.000	53.21	7.0	1.01	6.9	2.93	4.40	1.35	2.170
Averages for the season	550.3	47		10/32	29.01	26.269.7	43.76	8.05	1.247	6.455	2.86	4.54	1.60	1.787

TABLE 2.

Analyses of Fruit (Duncan) from Test Trees, Grove B, Vega Baja.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 6	379	64	Y. G. T.	1/4	24.78	24.216	43.64	8.5	1.38	6.1	2.93	5.14	2.09	1.401
November 3	317	64	G. S. Y. T.	1/4	25.66	20.288	41 59	9.5	1.52	6.2	2.19	5.38	3.07	0.713
December 29	406	64	Y. G.	1/4	28.57	26.112	50.00	8.0	1.13	7.1	3.10	5.14	1.92	1.614
January 18	466	64	Y. G. T.	5/16	29.46	29.824	47.82	7.7	1.10	7.0	3.50	5.87	2.25	1.555
February 13	684	36	Y. G. T.	1/4	27.03	24.624	42.66	8.6	1.13	7.6	3.67	6.60	2.81	1.306
Averages for the season	450.8	58		8/32	27.10	25.028	45.74	8.46	1.252	6.757	3.08	5.217	2.03	1.517

NOTE.—In working with the fruit a system of noting the comparative amounts of coloring was devised. In the charts letters are used to represent these as follows: G., green; Y., yellow; T., tinge; S., slight; Q., quite. Various combinations are employed.

TABLE 3.

Analyses of Fruit (Duncan) from Test Tree, Grove D, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	560	54	Y. G.	5/16	28.80	30.240	41.03	7.8	1.25	6.2	2.69	5.38	2.57	1.046
October 20	535	54	Y. S. G. T.	3/8	30.84	28.890	42.93	8.6	1.25	6.9	3.50	5.14	1.52	2.302
December 8	538	54	Y. G.	5/16	28.57	29,052	42.85	8.9	1.21	7.3	2.69	5.63	2.82	0.953
January 18	545	54	Y. S. G. T.	1/4	29.53	29,430	44.36	8.9	1.25	7.1	2.69	5.14	2.33	1.154
Averages for the season	544.5	54		10/32	29.43	29,403	42.79	8.55	1.24	6.895	2.89	5.32	2.31	1.251

TABLE 4.

Analyses of Fruit (Duncan) from Test Tree, Grove E, Palo Seco.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert to sucrose
September 28	550	54	G. Y. T.	5/16	25.58	29.700	29.49	9.3	1.59	5.8	3.10	5.87	2.65	1.169
Novembor 3	655	50	G. Y. T.	11/32	25.73	33.750	37.68	8.8	1.16	7.6	3.50	6.36	2.74	1.277
December 2	701	46	G. Y. T.	1/4	22.99	38.246	41.00	9.1	1.10	8.3	3.10	6.11	2.89	1.072
January 22	483	64	G. Y. T.	1/4	28.50	30.912	47.35	9.3	1.23	7.5	3.67	5.63	1.84	1.994
Averages for the season	599.7	54		9/32	25.67	31.402	38.88	9.12	1.27	7.181	3.34	5.87	2.53	1.320

TABLE 5.

Analyses of Fruit (Duncan) from Test Tree, Grove G, Trujillo Alto.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert to sucrose
September 28	600	46	G. Y. T.	9/32	21.03	27,600	38.45	8.8	1.39	6.3	2.93	5.63	2.58	1.135
November 6	450	60	G. Y. T.	1/4	26.28	27,000	45.08	9.5	1.26	7.5	3.67	5.87	2.08	1.764
December 7	498	54	G. Y.	5/16	30.64	26,892	44.70	9 2	1.27	7.2	3.50	5.63	2.01	1.741
January 24	530	54	G. Y. T.	1/4	31.13	28.620	40.81	10.0	1.03	9.7	4.16	6.60	2.42	1.710
Averages for the season	519.5	54		9/32	27.27	27,528	42.26	9.37	1.237	7.578	3.565	5.953	2.27	1.570

TABLE 6.

Analyses of Fruit (Duncan) from Test Tree, Grove I, Bayamón.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
september 25	550	56	G. Y. T.	5/16	25.53	30,800	41.34	8.8	1.29	6.8	3.10	5.38	2.16	1.435
October 9	625	46	G. Y. T.	5/16	29.17	28,750	38.72	8.6	1.29	6.7	2.69	4.89	2.08	1.293
October 23	637	46	G. Y. T.	9/32	28.87	29,302	43.47	8.6	1.19	7.2	2.69	5.38	2.57	1.046
November 3	643	46	G. S. Y. T.	9/32	27.27	29,578	42.33	8.6	1.14	7.5	2.69	5.14	2.33	1.154
November 21	551	54	G. S. Y. T.	5/16	27.38	29.754	41.22	8 6	1.10	7.8	2.69	5.38	2.57	1.046
December 8	810	36	G. Y.	7/16	31.07	29,160	42.70	8.5	1.05	8.1	2.93	4.89	1.84	1.592
December 29	713	36	Y. G. T.		28.14	25,668	42.35	8.5	1.00	8.5	2.93	5.63	2.58	1.138
January 18	658	46	Y. S. G. T.	9/32	26.58	30,268	42.36	8.7	1.10	7 9	3.50	5.38	1.76	1.988
February 9	725	36	Y. S. G. T.		27.90	26,100	42.57	8.6	1.00	8.6	3.67	5.87	2.08	1.766
March 9	658	46	Y. S. G. T.	5/8	24.05	30,268	48.10	8.9	1.08	8.2	....	.....	.....	.....
Averages for the season	657	45		10/32	27.59	28,9648	42.51	8.64	1.124	7.686	2.987	5.32	2.218	1.346

TABLE 7.

Analyses of Fruit (Duncan) from Test Tree, Grove J, Bayamón.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	588	46	G. S. Y. T.	3/8	28.33	27,048	40.53	8.4	1.51	5.6	3.03	4.89	1.74	1.741
October 6	583	46	G. Y. T.	3/8	30.80	26,818	38.84	8 9	1.49	6.0	3.10	5.38	2.16	1.435
October 23	579	46	G. S. Y. T.	11/32	27.26	26,634	44.89	9.1	1.33	6.8	3.10	6 11	2.89	1.072
November 3	583	46	G. S. Y. T.	11/32	29.14	26,818	43.40	8.6	1.27	6.8	2.69	4.89	2.08	1.293
November 21	551	54	G. S. Y. T.	5/16	27 53	29.754	43.63	8.4	1.17	7.2	2.69	4.89	2.08	1.293
December 8	650	46	G. Y.	3/8	29.33	29,900	42.66	9.0	1.22	7.4	3.10	5.63	2.41	1.286
December 29	583	54	Y. G.	5/16	27.86	31,482	44.29	9.0	1.20	7.5	3.50	5.38	1.75	1.988
January 18	633	46	Y. Q. G. T.	1/4	29.05	29,118	40.54	9.2	1.36	6.7	3.50	5.38	1.76	1.988
February 9	533	50	Y. G. T.	.....	28.81	26,650	48.44	9.0	1.20	7.5	3.67	6.11	2.32	1.581
March 9	558	46	Y. G. T.	.....	28.58	25,668	46.11	9.5	1.40	6.7	3.91	6.11	2.08	1.879
Averages for the season	584.1	48		11/32	28.66	27,996	43.33	8.91	1.315	6.775	3.23	5.47	2.128	1.517

TABLE 8.

Analyses of Fruit (Duncan) from Test Tree, Grove N, Vega Alta.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar invert	Cane sugar	Ratio invert to sucrose
September 25	566	46	G. Y. T.	1/4	26.13	26,036	43.92	8.2	1 28	6.4	3.08	5.14	1.94	1.587
October 5	516	64	Y. G.	9/32	29.41	33,024	38.03	8.7	1.24	7.0	2.69	5.63	2.82	0.953
October 23	525	54	G. Y. T.	9/32	27.09	28,350	42 98	8.9	1.27	7.0	3.50	5.38	1.76	1.988
November 3	375	64	G. S. Y. T	8/32	28.11	24,000	39.57	8.6	1.07	8.0	2.44	5.14	2.58	0.930
November 21	400	80	G. S. Y. T	7/32	22.97	32,000	40.04	9.6	1.43	6.7	3.10	6.11	2.89	1.072
December 8	450	64	G. Y. T.	3/8	37.50	28,800	45 37	7.5	1.00	7.5	2.93	4.40	1.35	2.170
December 29	541	64	Y. G.	.....	24.61	34,624	46.15	9 0	1.15	7.8	3.50	5.38	1.76	1.988
January 18	400	63	Y. G. T.	1/4	28.12	25,200	46.12	8.5	.91	9.3	3.50	6.36	2.74	1.277
Averages for the season	471.6	62		8/32	27.99	29,008	42.77	8.62	1.166	7.392	3.092	5.438	2.23	1.386

From the above tables of individual tree records the averages of all samples picked on the same date were found, and tabulated as shown below:

TABLE 9.

Showing the Mean Composition of Fruits Sampled from Eight Different Groves on Specified Succeeding Dates.

Date picked	Average Weight	Per cent skin	Per cent juice	Solids in juice	Citric acid	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to cane sugar
September 25 ...	611.5	28.06	39.42	8.4	1.36	6.2	2.98	5.11	2.18	1.36
October 6.....	584	29.65	43.78	8.5	1.36	5.1	2.84	5.24	2.28	1.24
October 24.....	617	28.60	43.48	8.5	1.20	6.3	3.05	5.35	2.17	1.40
November 3 ...	583	27.49	43.39	8.7	1.12	7.2	2.95	4.78	2.17	1.36
November 21 ...	582	26.27	45.15	8.6	1.19	7.3	3.29	5.40	1.99	2.06
December 8....	596	29.96	42.88	9.2	1.14	7.5	3.10	5.35	2.12	1.46
December 29....	665	27.58	44.30	8.9	1.11	8.0	3.38	5.62	2.11	1.60
January 22.....	580	28.39	45.13	8.8	1.15	7.6	2.78	5.41	1.80	1.54
Averages for the season	602.31	28.25	43.57	8.7	1.205	7.23	3.045	5.258	2.102	1.448

The averages representing the mean composition of the fruit for each individual tree for the season, have been grouped together as shown in the following:

TABLE 10.

Showing Mean Composition of Fruit for Each Tree for the Season.

DUNCAN FRUIT (1916–1917).

Grove	Average weight in grams	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric) (anhydrous)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar to sucrose
A	550·3	47	5/16	29.01	26,269.7	43.76	8 05	1.247	6.455	2.86	4 54	1.60	1.047
B	450.8	58	1/4	27.10	25,020.8	44.74	8.46	1.252	6.757	3.08	5.217	2.03	1.517
D	544.5	54	5/16	29.43	29,433	42.79	8.55	1.240	6.895	2 89	5.32	2.31	1.251
E	599.7	54	9/32	25.67	31,402	38.88	9.12	1.270	7.181	3.34	5 87	2.53	1.320
G	519.5	54	9/32	27.27	27,528	42.26	9.37	1.237	7.578	3.565	5.953	2.27	1.570
I	657.	45	5/16	27.59	28,964.8	42.51	8.64	1.124	7.686	2.987	5.320	2 218	1.346
J	584.1	48	11/32	28.66	27,996	43.33	8.91	1.315	6.775	3.23	5.47	2.128	1.517
N	471.6	62	1/4	27.99	29,008	42.77	8.62	1.166	7.392	3.092	5.438	2.23	1.386

DISCUSSION OF RESULTS.

A discussion of the figures presented, now follows. The discussion will be by topics and very brief, with the sole purpose of bringing out the salient facts as revealed by this set of tables. Each set of tables for the different varieties and seasons will be successively taken up in the same fashion, and after each set has been discussed separately, a general discussion, establishing the proper relations will be given.

For convenience in the discussion the individual trees will be referred to in this particular instance by the letter designating the grove where they were located.

DUNCAN, 1916–1917.

Size.—See tables. Out of 53 samples picked and measured, seventeen gave an average size of 46, fifteen sized 54, nine were 64's and five were 36's. The rest were distributed one apiece between sizes ranging from 80 to 40. As seen, the sizes ranged mainly between 36's and 64's, the most common being 46 and 54.

The size of the fruit was not affected in any fixed manner by the date of picking, within the limits of time set forth in the tables.

Weight.—The average weight per fruit fluctuated, naturally, as the sizes, although it differed even for fruits of the same size. Contrary to expectations, higher averages of weights per fruit were associated with lower contents of juice for the same size of fruit. Take, for instance, the samples of the trees on grove A, picked on October 23, November 3, and November 21, all of size 54. Their percentage of juice increased in the order mentioned, while the average weight per fruit decreased in the same order, there being a difference of 102 grams per fruit between the first and last, in favor of the first. Again in the samples picked from tree B on October 6, November 3, December 29 and January 18, all of average size 64, it may be noticed that the second sample, with a higher juice content than the first, shows a smaller weight per fruit, while the fourth sample, with a lower juice content than the third, shows a higher weight per fruit. This in spite of the fact that the solids in juice are higher in the second sample than in the first and lower in the fourth sample than in the third.

In the samples picked from tree D, all of size 54, the first sample, with the lowest juice content of all, shows the highest weight per fruit while the last with the highest juice content of all shows much lower weight per fruit than the first. The second and third samples,

with about the same juice content, exhibit very nearly the same weight per fruit; still, the slight difference there is, is in favor of the fruit with the lower juice content. In the last two samples, size 54 of tree G; in the second, third, and fourth samples of tree I, size 46; in the first four samples of tree J, size 46; and in fact, in practically every instance where fruit from the same tree and of the same size are compared, the same relation exists.

It seems, then, that the weight per fruit changes in a direction opposite to the juice content, independent of the solids in solution and of the ratio. Turning now to the tables of averages (see tables 9 and 10) we find the same relations to exist in a general way.

Taking the weight of fruit per box, to obviate the differences due to sizes, we find again that no definite tendency can be detected.

Per cent juice.—The general trend of the changes in juice content is toward an increase as the season advances. In some cases there may be a little fluctuation, but there is always a perceptible tendency to increase, while in many instances the increase is shown without interruption. This may be seen from an examination of both the individual tree records and the tables of averages. (See tables No. 1–10.)

In tree A, except for a slight break in the sixth sample, the figures show an uninterrupted chain of increases, and even the sample just excepted shows a higher juice content than any of the first three. The last sample is the highest in juice, and contains 15.33 per cent more than the first, which is the lowest. The average juice content of all the samples contains 6.08 per cent more juice than the first sample.

There is some fluctuation shown by tree B, but the general trend is upward, as shown by the fact that the average of all the samples comes up higher than the first by 2.10 per cent.

Tree D shows a practically continuous increase. The same is true of tree E. Trees G, I, and J show fluctuations but in every instance the average is higher than the content of the first sample.

It is only in tree N that the tendency to increase is not clearly shown; however, the last three samples in this tree are higher each than any of the preceeding ones.

The table of averages shows the tendency of the per cent juice to increase very plainly. All percentages are higher than the first, and the average of the last four figures is higher than the average of the three figures immediately preceeding them, which follow the

first in succession. Besides, the average of all figures is higher than the first by 4.15 per cent.

It may be stated, then, that the per cent juice increases as the season advances.

The average for all of the trees for the whole season was 43.57 per cent. (See table 9.)

Per cent skin.—No regularity can be detected in the variations of this factor. However, there is a slight tendency to increase as shown by the averages of the different trees. The table of averages (No. 9), on the other hand, shows this item to be rather constant throughout the season.

Thickness of skin.—The thickness of the skin fluctuates between somewhat narrow limits. The average for each individual tree is usually equal to the thickness shown by the first sample, or slightly less. In general, then, it may be said that the thickness is rather constant, tending to a very slight diminution as the season advances.

Per cent solids in juice.—Out of the eight trees tested the averages for the season were less than the first figure in three instances, greater in three other instances and in the remaining 2 samples it was equal. This makes the solids practically constant. However, in the table of averages of all trees for the season a slight tendency to increase is manifested both in the figures given for the succeeding dates and in the total averages (see table 9).

From the table of averages it may be seen that the lowest average for any date was 8.4 per cent, the highest 9.2 per cent, and the total average 8.7 per cent.

Per cent acid.—The per cent acid diminishes very perceptibly as the season advances. In every tree considered the average for the season for the tree is lower than the content shown by the first sample analyzed. Not only this, but with very few exceptions all the figures following are lower than the first. In the table of averages there is a continued, uninterrupted falling down in the percentage of acid, the only exception being the very last figure which is slightly higher than the two previous ones. The average of all the figures given for the different dates is also lower than the first. *There is no question, then, that the percentage of acid decreases as the season advances.* This shows that as Collison[1] found out in Florida, most of the acid, if not all, is formed at the beginning of the season.

Ratio of solids to acid.—As it was to be expected from what has been said in connection with *total solids* and *per cent acid*, this ratio

increases very perceptibly all through the season. Only in case of tree A are some fluctuations noticed, and even here the general tone is upward as shown by the fact that of the seven figures following the first, four are higher than the first, as is also the average for the season. In all the other trees, all figures after the first are higher than the first, and of course the average ratio for each tree for the season is higher than the ratio shown by the first sample.

There is no question, then, that the ratio of solids to acid increases as the season advances.

Of the eight trees tested, four made an average ratio of more than 7 for the season (see table 10). Of those that did not average 7 for their ratio, 3 came within less than 0.3 of making it. Tree A, which averaged only 6.455, never showed a ratio of 7, although it came up to 6.9 on November 21. Of the 7 remaining, two showed a ratio of 7 in October, 3 in November and 2 in December.

Color.—If we notice now the color of the fruit in connection with the ratio we will find—

1. That there were 10 samples marked "G. Y. T." (green, yellow tinge) which ranged in ratio from 5.6 to 9.7, and showed an average ratio of 6.96.

2. There were 8 samples marked "G. S. Y. T." (green, slight yellow tinge). These samples ranged in ratio from 6.2 to 8.0, and their average ratio was 7.12.

3. Three samples were marked "G. Y." (greenish yellow). The ratio for these samples ranged from 7.2 to 8.1 and came up to an average of 7.56.

4. Seven samples were marked "Y. G." (yellowish green) and ranged from 6.2 to 7.8 in ratio. Their average ratio was 7.11.

5. Seven samples were marked "Y. G. T." (yellow, green tinge) and ranged in ratio from 6.1 to 9.3, and showed an average ratio of 7.53.

6. Seven samples whose color was determined as "Y. S. G. T." (yellow, slight green tinge) showed a minimum ratio of 6.0, and a maximum of 8.6. The average ratio for this group of samples was 7.37.

If the color of the fruit is to be taken as a prominent factor in determining the ripeness of grapefruit, then certainly the fruit here reported reached a ratio of 7 before they were perfectly ripe. Only

the first lot of samples noted, marked "G. Y. T." (green yellow tinge), fell below the ratio of 7 in average, and even in this case the average shown, 6.95, is practically 7, and may be considered as 7 for all practical purposes. In this same lot of samples ratios larger than 7, going as high as 9.7, were obtained in individual samples. In all the other cases, in none of which was the fruit perfectly yellow, and in most of which the green predominated, the average ratio was greater than 7, and ratios above 8 were reached in many instances.

Per cent sugar.—Within the limits of the ratios exhibited by the samples examined, the total sugars remained practically constant, with perhaps, a very slight tendency to increase. Thus, out of the eight trees tested, the averages for the season for three of the trees (see table 10) were lower than the per cent shown by the first sample analyzed, 4 trees showed averages higher than the per cent found in the first analysis, and in one tree the two figures coincided. The minimum average found was 4.54 per cent total sugars, for tree A, in which the ratio never reached 7. The highest average was 5.933 per cent total sugars for tree G, in which the average ratio was 7.58. If we arrange the average ratios for the season for the different trees in ascending order, and opposite them write the per cent of total sugars, the fact will be revealed that the total sugars increase in a general way with the ratio, although the variation is not a regular one.

Tree	Ratio	Total sugars
A	6.450	4.54 per cent
B	6.757	5.21 per cent
J	6.775	5.47 per cent
D	6.895	5.32 per cent
E	7.180	5.87 per cent
N	7.290	5.438 per cent
G	7.578	5.953 per cent
I	7.686	5.320 per cent

However, it may be noticed that the increase is continuous until a ratio approaching 7 is reached, when the fluctuations begin. This shows that the differences noticed among the various samples having a ratio of 7 (more or less) are due to individual tree variations, and that the formation of sugar ceases or proceeds at a very slow rate when this ratio is reached. This is a very strong point in favor of the assumption that this fruit is mature when it reaches a ratio of 7, and not before.

The table of averages bears out all of the above statements. Turning now to invert sugar and sucrose, and taking the average for each tree for the season (see table 10). Let us arrange the ratios of solids to acid again in ascending order, and opposite each ratio write their corresponding percentages of invert sugar and sucrose thus:

Ratio solids to acid	Invert sugar	Sucrose	Ratio invert sugar to sucrose
6.45	2.86	1.60	1.787
6.76	3.08	2.03	1.517
6.77	3.23	2.13	1.517
6.89	2.89	2.31	1.251
7.18	3.34	2.53	1.320
.....	.....	.....	.....
7.39	3.09	2.23	1.386
7.57	3.56	2.27	1.570
7.68	2.98	2.21	1.340

It may be noticed that the sucrose increases steadily until the ratio 7.18 is reached, and henceforth it decreases. The invert sugar increases almost continuously, except for only one break, in the fourth figure from the top of the column; however, all figures after the first are higher than the first. Moreover, the average of the last three figures for invert sugar, 3.21 per cent, is higher than the average for the first five figures, 3.08 per cent. This tends to show that the sucrose increases until a ratio of 7, more or less, is reached, while the invert sugar increases continuously. Coupling these facts with the observation previously noted, that the total sugars increase until a ratio of 7 is reached, the conclusion may be drawn that after a ratio of 7 obtains, inversion of the sucrose and decomposition of invert sugar begin. This is again a very strong argument in favor of considering a ratio of 7 as indicating maturity of the fruit.

Summarizing the above comments, we have that the Duncan grapefruit analyzed from September, 1916, to February, 1917, showed the following characteristics:

1. The size of the fruit was very near 54.

2. Their average weight varied between 450.8 and 659.0, the average for the season being 602.31 grams per fruit. The weight showed slight and irregular gains, especially if the weight per box is considered. The unexpected observation was made that among fruits of the same size, those with a lower percentage of juice exhibited more weight per fruit than those containing more juice.

3. There were not great variations in the juice content among the different trees, all fluctuating between 42.26 per cent and 45.74 per cent, with the exception of one tree, which had only 38.88 per cent. The juice increased, but to a very small extent, the range among the averages for different dates being 39.42 per cent to 45.15 per cent, the average for all the trees for the season (see table 9) being 43.57 per cent.

4. The solids contained in solution by the juice ranged among the trees compared between 8.05 and 9.37. The solids were practically constant for a given tree, with a very slight increase as the season advanced. The average for the whole season, for all the trees, was 8.7 per cent.

5. The acid decreased steadily and visibly all along the season, the range being from 1.36 to 1.15 (see table 9), and the average for the whole season 1.203. The variation among trees, if tree N is excepted, is very small, thus exhibiting much uniformity.

6. The ratio of solids to acids averaged less than 7 in four trees, A, B, C, and J, and more than 7 in the other four. It increased steadily all through the season, going up to 8 on December 29th. The average for all trees for the season was 7.23. All of the trees, except tree A, reached a ratio of 7 during the course of the season between the extreme dates of October 5th and December 29th. The highest ratio reached by tree A was 6.9 on November 3rd. The average of all the trees came up to 7.2 on November 3rd.

7. The total sugars increased until a ratio of 7 was obtained. From this point on the sucrose suffered inversion, and no constant increase in total sugars could be noticed. The invert sugar increased continually. The averages for the season were 5.258 for total sugars, 3.045 for invert sugars, and 2.102 for sucrose. There was not much variation among the individual trees (see table 9), the total sugars specially showing uniformity. The inversion of sucrose after a ratio of solids to acid of 7 is obtained, is unmistakebly shown.

8. The per cent skin and the thickness of skin changed in a very irregular fashion, and the latter item only between very narrow limits. Between the ratios that obtained, they may be considered constant.

9. The invert sugar content has been higher than the sucrose content in every case.

All of the above observations point strongly to the conclusion that the juice of Duncan grapefruits contains a ratio of solids to acid equal to at least 7 when they are mature. They seem to reach this stage by the first week of November.

MARSH'S SEEDLESS, SEASON 1916–1917.

The composition of the fruits picked on succeeding dates from four trees of the Marsh's Seedless variety are given below for each tree in tabular form:

INDIVIDUAL TREE RECORDS.

Mean composition of fruit for the whole season, per tree and on succeeding dates:

TABLE 11.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove B, Vega Alta.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 23	439	54	Y. S. G. T.	9/32	28.07	23,706	48.35	7.8	1.16	6.7	2.44	4.40	1.84	1.326
November 21	440	63	G. Y.	5/16	23.14	27,720	51.50	7.6	1.05	7.2	2.69	4.65	1.84	1.462
December 29	733	46	Y. G. T.	5/16	26.13	33,718	45.45	8.0	1.00	8.0	2.93	5.14	2.09	1.402
January 18	508	54	Y. S. G. T.	9/32	18.03	27,432	46.93	9.7	1.38	7.0	3.50	5.81	2.19	1.598
Averages for the season	530	54		19/64	24.31	28,894	48.06	8.27	1.147	7.21	2.89	4.983	1.59	1.452

TABLE 12.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove L, Río Piedras.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 3	499	36	G. Y. T.	3/8	33.23	17,964	48.99	7.4	1.25	5.9	2.69	4.65	1.84	1.462
October 20	471	54	G. S. Y. T.	3/8	30.30	25 434	45.91	7.5	1.15	6.5	2.44	4.16	1.60	1.525
November 14	446	54	G. S. Y. T.	3/8	31.21	24,084	46.15	7.3	1.10	6.6	3.67	4.16	0.37	9.918
November 21	468	54	G. S. Y. T.	9/32	25 08	25,272	48.59	7.1	1.00	7.1	2.69	4.05	1.84	1.462
December 20	445	56	G. Y. T.	.....	28.03	24.920	53.13	7.3	1.00	7.3	3.10	4.40	1.18	2.627
January 24	558	54	Y. G. T.	1/4	29 85	30,132	46.41	6.9	.93	7.4	2.69	4.16	1.35	1.992
February 24	534	56	Y. S. G. T.	1/4	29.14	29,904	49.90	7.2	.95	7.6	2.93	3.91	.86	3.406
Averages for the season	483	52		10/32	29.54	25,387	47.71	7.24	1.054	6.86	2.887	4.245	1.291	2.236

NOTE.—In working with the fruit a system of noting the comparative amounts of coloring was devised. In the charts letters are used to represent these as follows: G., green; Y., yellow; T., tinge; S., slight; B., bright; Q., quite. Various Combinations are employed.

are employed.

TABLE 13.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove M.

Date picked	Average weight	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
September 22	616	36	Y. G. T.	7/16	41.72	22,176	32.04	8.1	1.00	8.1	3.50	5.63	2.01	1.741
October 6	500	46	G. Y. T.	7/16	34.85	23,000	38.45	8.2	1.38	5.9	2.69	5.14	2.33	1.111
October 23	441	64	G. Y. T.	17/32	37.92	28,224	36.92	7.8	1.40	5.6	2.69	4.40	1.59	1.691
November 3	466	54	G. S. Y. T.	15/32	32.44	25,164	38.62	7.8	1.24	6 8	2.44	4.16	1.60	1.525
November 21	458	54	G. S. Y. T.	3/8	34.54	24,732	40.25	7.9	1.22	6.5	3.10	4.89	1.67	1 856
December 8	612	46	G. S. Y. T.	3/8	38.11	28,152	42.18	7.8	1.10	7.1	2.69	4.89	2.08	1.293
December 29	537	54	Y. G.	1/2	35.66	28,958	41.86	7.5	1.10	6 8	2.93	5.14	2.09	1.401
January 18	475	54	Y. S. G. T.	1/2	35.08	25,650	42.45	7.5	1.10	6.8	3.50	4.40	.78	4.487
March 9	561	46	Y. S. G. T.	5/16	32.27	25,806	46.52	7.1	.95	7.5	2.93	4.16	1.11	2.639
February 9	493	64	Y. G. T.	5/8	33.10	31,552	46.97	7.6	1.06	7.2	3.67	5.14	1.35	2.718
Averages for the season	516.3	52		29/64	35.57	26,345	40.62	7.73	1.155	6.69	3.011	4.758	1.661	1.812

TABLE 14.

Analyses of Fruit (Marsh's Seedless) from Test Tree, Grove N.

SEASON 1916–1917.

Date picked	Average weight	Per cent skin	Thickness of skin in inches	Color	Average size	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar cane to sucrose	Weight of fruit per box
October 6	525	26.11	1/4	G. Y. T.	46	45.28	7.9	0.85	9.4	2.93	5.14	1.99	1.473	24,130
October 23	487	27.62	1/4	G. Y. T.	64	45.60	8.5	1.19	7.1	.....	.....	.....	.....	31,168
November 3	371	28.87	3/4	G. S. Y. T.	60	40.49	9.6	1.27	7.5	2.93	5.87	2.82	1.039	22,260
November 21	541	25.10	9/32	G. S. Y. T.	54	47.53	8.5	1.00	8.5	3.91	5.63	1.60	2.443	29,214
December 8	562	20.00	5/16	G. Y.	54	43.20	9.0	1.15	7.9	2.69	4.89	2.08	1.293	30,348
December 29	441	24.61	5/16	Y. G.	64	46.15	9.0	1.15	7.8	3.50	5.38	1.76	1.988	28,224
January 18	287	24.05	7/32	Y. S. G. T.	72	47.75	8.5	1.03	8.2	4.40	6.11	1.59	2.767	20,664
Averages for the season	459	26.62	21/64		59	45.14	8.7	1.091	7.97	3.373	5 448	1.973	1.709	31,001

TABLE 15.

Showing Biweekly Analyses of Fruit Picked from Different Groves, B. L. M. N.[1]

SEASON 1916–1917) MARSH'S SEEDLESS.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Invert sugar	Cane sugar	Total sugar	Ratio invert to cane sugar	Thickness of skin	Average size	Weight per box in March
September 22	616	32.04	41.72	8.10	1.100	8.10	5.50	2.01	5.63	1.741	7/16	36	22,176 Grm.
October 3–6	508	31.39	42.57	7.83	1.273	6.15	2.77	2.08	4.97	1.331	11/32	43	21,844 "
October 20–23	459.5	31.30	42.95	7.90	1.225	6.74	2.52	1.48	4.32	1.702	12/32	59	27,110 "
November 3–14	427.6	30.84	41.82	8.23	1.200	6.86	3.01	1.60	4.73	1.881	12/32	56	23,945 "
November 21	476.7	27.44	49.35	7.83	1.067	7.33	3.20	1.57	4.39	2.038	10/32	56	26,695 "
December 8	587	34.05	42.69	8.40	1.125	7.46	2.59	2.08	4.89	1.293	11/32	50	29,350 "
December 20–29	539	33.81	45.51	7.90	1.062	7.43	2.96	1.95	5.08	1.518	12/32	55	29,645 "
January 18–24	457	26.75	45.88	8.15	1.110	7.24	3.54	1.60	5.12	2.212	10/32	59	26,963 "
February 9	493	33.10	46.97	7.60	1.060	7.17	3.67	1.35	5.14	2.718	5/8	64	31,552 "
February 24	534	29.14	49.90	7.20	0.950	7.507	2.93	0.86	3.91	1.407	1/4	56	29,901 "
Averages of all the trees for season	509.78	30.98	44.94	7.91	1.117	7.08	3.079	1.658	4.825	1.857	22/32	53	26,914

TABLE 16.

Showing Mean Composition of Fruit for Each Tree for the Season.

MARSH'S SEEDLESS (1916–1917).

Grove	Average weight in grams per fruit	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grms.	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar to sucrose
B	530	54	9/32"	21.31	28,894	48.06	8.27	1.147	7.21	2.890	4.983	1.990	1.452
L	483	52	5/15"	29.54	25.387	47.73	7.24	1.054	6.86	2.887	4.245	1.291	2.236
M	516.3	52	14/32"	35.57	26.345	40.62	7.73	1.155	6.69	3.011	4.758	1.661	1.812
N	459	59	10/32"	26.62	31.001	45.14	8.7	1.091	7.91	3.373	5.448	1.973	1.709

[1] On each of the dates noted, 12 fruits were picked from each tree, and each sample was separately analyzed. The results of each set of four samples were then averaged, and the averages obtaiend are tabulated below.

DISCUSSION OF RESULTS OBTAINED WITH MARSH'S SEEDLESS (1916–17).

Weight and size.—Tree B. The tendency is to increase on the part of the weight; this is shown both by the weight of the individual fruits and by the weight per box. Notice that the first and last samples collected are both size 54, and that the weight per fruit of the first sample, which contains a higher per cent of juice is less than the weight per fruit of the second sample, with a lower juice content. This confirms observations made on Duncan fruit.

The size of the fruit is variable.

Tree L.—Again a tendency to increase in weight is noticed, especially among the figures showing weight per box. The samples picked on October 20, November 14, November 21, and January 24 are all of size 54. On inspection of the table it will be found that the samples with less juice show the greater weight per fruit.

The size of the fruit is tolerably uniform.

Tree M.—A slight tendency to increase in weight as shown by the weight per box. Compare the samples picked on November 3rd, November 21st, December 29th, and January 18th, all of size 54. The samples containing the most juice show the lower average weight per fruit.

Tree N.—There is much fluctuation.

Again, if fruits of the same size are compared as to weight, the larger weights are shown by the fruits having the smaller percentages of juice. Compare for instance the samples picked on November 21st and December 8th, both of size No. 54, and the samples picked on October 23rd, with that picked on December 29th, of size No. 64.

The table of averages shows an increase in weight per box as the season advances, but fails to support the assumption that higher weights per fruit are associated with lower juice contents.

The Marsh's Seedless, then, shows a tendency to increase in weight as the season advances, as shown by the weight per box. They, too, as the Duncans, appear to have more weight when the per cent juice is lower, if the comparison is made between fruits of the same size and from the same tree, but this is not uniformly so.

Per cent juice.—The tendency is to increase in fruits that have not reached yet a ratio of 7, as instanced by tree L. The first three samples picked from this tree averaged a ratio of solids to acid of 6.33 and their average juice content was 45.35 per cent. The last

four samples had all ratios larger than 7 averaging 7.35, and their juice content was 49.50 per cent. Not only this, but in the first three samples each increase in ratio was accompanied by a corresponding increase in juice. After the ratio of 7 is attained, the increase is not so regular, and the variations show considerable fluctuations, although the range is rather upward than downward.

The table of averages of all the trees through the whole season support the above conclusions (see table 15). Thus the averages corresponding to October 3–6th, October 20th–23rd and November 3rd–14th, all have correspanding ratios lower than 7 (an average of 6.58), and the juice percentages corresponding to them average only 42.44 per cent. The rest of the average ratios are all higher than 7 (an average of 7.371) and the corresponding juice contents range from 41.72 to 49.90, averaging 46 per cent.

The juice in the Marsh's Seedless increases with perceptible regularity as the ratio of solids to acid increases, until a ratio of 7 is reached. Beyond this ratio considerable fluctuation occurs. This seems to point to the assumption that the Marsh's Seedless fruits reach maturity when they show a ratio of 7.

Per cent skin.—The skin decreases fairly steadily until a ratio of 7 is reached. Thereafter considerable fluctuation is noticed. With few exceptions the higher percentages of skin correspond with lower ratios. In tree B the first sample picked with a ratio of 6, had the highest percentage of skin, 28.07. Among the rest of the samples, all with ratios above 7, fluctuations occurred.

In tree L, the first three samples show ratios below 7, ranging from 5.9 to 6.6 with an average of 6.33, and their content of skin ranges from 33.23 per cent to 30.30 per cent with an average of 31.58 per cent. The succeeding samples have ratios ranging from 7.1 to 7.6 with an average of 7.35, and their percentages of skin fluctuate between 25.08 and 29.85 with an average of 28.02.

In tree M, arrange the ratios of solids to acids in an ascending order, and write opposite to each ratio its corresponding per cent skin, thus:

Ratio of solids to acids.	Per cent skin.
5.6	37.92
6.0	34.85
6.3	32.44
6.5	34.54
6.8	35.66
6.8	35.08

Ratios.	Per cent skin.
7.1	38.17
7.2	33.10
7.5	32.27
8.1	41.72

Taking the averages of all samples with ratios up to and including 7.1, and of all those having ratios larger than 7 we get 35.51 per cent for the former and 35.69 per cent for the latter. In this instance no difference appears between the fruits with ratios below and above 7. It should be noticed, however, that except for the two exceptional cases of the samples with ratio 7.1 and 8.1 the individual figures suggest a decrease.

Tree N, does not show any fixed tendency, and the figures fluctuate considerably. It should be noticed that all ratios here are larger than 7.

Coming now to the table of averages of all trees for the whole season, and arranging as before, the average ratios in an ascending order with the corresponding percentages of skin opposite, we get:

Average ratio of solids to acid.	Average per cent skin.
6.15	31.39
6.74	31.30
6.86	30.84
7.17	33.10
7.33	27.44
7.34	26.75
7.36	32.04
7.43	33.81
7.46	34.05
7.507	29.14

Averaging the percentages of skin for all ratios below 7, a skin content of 31.04 per cent is obtained. The percentages of skin for all ratios above 7 average 30.90, thus showing a decrease as the ratio increased to 7.

The percentage skin, then, though within rather narrow limits and in an irregular fashion, suffers a decline as the ratio of the fruit approaches 7.

Thickness of skin.—After a ratio of 7 is reached no definite tendency is manifested. Before a ratio of 7 is reached, however, the thickness of skin diminishes as the ratio increases.

Thus, in tree L the thickness for the first three samples averaged

3/8", while the thicknesses that follow, for fruits with ratios greater than 7, do not go beyond 9/32" and average approximately 1/4".

In tree M the samples with ratios below 7 average a thickness of 15/32" while those with ratios above 7 average 14/32".

In the other two trees all ratios reach and go beyond 7 (except for one sample in tree B, which has a ratio of 6.7), and no definite tendency is manifested. Considerable fluctuation occurs.

Turning to the table of averages for all the trees throughout the season (table No. 15), we find that the average of all the averages given for fruit with ratios lower than 7 is over 14/32", while the average of all averages given for fruit with ratios higher than 7 is less than 12/32". *There is, then, a tendency on the part of the skin to diminish in thickness as the ratios increase, which is chiefly noticeable before the fruit obtains a ratio of 7.*

Per cent solids in juice.—The solids for this fruit during this season may be considered as practically constant. In tree B an increase may be noticed, and so also in tree N, although to a lesser extent. Tree M, on the other hand, as well as the table of averages, shows a diminution, while in tree L this item may be considered as fairly constant. These observations are in accord with those made on the Duncan fruit.

The highest average shown for any tree was 8.7 for tree N, the lowest 7.225 for tree B, and the average of all the trees was 7.91. Among the averages of all trees for different dates, the lowest was 7.20 on February 24th, and the highest 8.40 on December 8th. Evidently these fruits contain less solids in solution than the Duncans.

Per cent acid.—Two things are to be noticed. First, that the per cent acid keeps on increasing until about November 21st, when it begins to decrease; and second, that, in general, the per cent acid varies in opposite direction to the ratio of solids to acids. That there is a very marked decrease in this factor is very plainly shown by the tables.

In tree B the decrease in acid begins on November 21st, the average of the last three samples, 1.143 being lower than the first figure, and so also the general average.

In tree L the decline in acid content takes place after November 21st, the average for the first three samples, with ratios below 7, being 1.166, while the average for the last four, with ratios above 7, is 0.97. The total average is less than the first figure, and the decrease in per cent acid follows closely the increase in ratio.

This close correspondency between decrease in acid and increase

in ratio is very strikingly shown, not only here but also by trees M and N.

Thus, arranging the ratios in their ascending order and writing opposite each their corresponding acid contents, we have:

TREE M.		TREE N.	
Ratio.	Acid per cent.	Ratio.	Acid per cent.
5.6	1.40	7.1	1.19
6.0	1.38	7.5	1.27
6.3	1.24	7.8	1.15
6.5	1.22	7.9	1.15
6.8	1.10	8.2	1.03
6.8	1.10	8.5	1.00
7.1	1.10	9.4	0.85
7.5	0.95		
8.1	1.00		

Turning now to the table of averages we find similar conditions established although fluctuations are more noticeable here. Arranging as before:

Ratios.	Per cent acid.
6.15	1.273
6.74	1.225
6.86	1.200
7.17	1.060
7.33	1.067
7.34	1.110
7.36	1.100
7.43	1.062
7.46	1.125
7.507	0.950

The decrease is plainly seen, and needs no further comment.

The per cent acid, then, decreases as the fruit matures and reaches higher ratios. Acid formation occurs only until a more or less definite point in the development of the fruit is reached, after which no more acid forms. This point seems to be reached almost at the same time that the ratio of 7 is reached.

Taking the averages of all the trees for different dates (see table 15) the lowest acid content, 0.95 per cent, occurred on February 24th, and the highest, 1.273, on October 3rd–6th. The average of all trees for the whole season was 1.117. This shows a lower acid content for Marsh's Seedless during 1916–17 than for Duncan fruit.

Ratio of solids to acids.—This ratio undoubtedly increases continuously until the ratio of 7 is fully established. Thereafter it continues to increase, but rather slowly, and with some fluctuations. It

should be noticed that this established ratio of 7, comes about some time near the 21st of November, coinciding thus with the time when the per cent acid begins to decline steadily and without interruption.

Tree B reached a ratio of 7 for the first time on November 21st, after which a ratio of 8 and one of 7 occurred in the two succeeding samples.

In tree L there is noticed a steady increase in the ratio, from 5.9 on October 3rd to 7.3 onNovember 21st, after which fluctuations occurred with very slight gains.

In tree M a ratio of more than 7 is obtained in the first sample. After this, a ratio of 6 which climbs up to 7.1 on December 8th is observed. The next two samples show ratios of only 6.8 each, after which the ratio does not fall below 7 again. It must be observed that for the three samples, corresponding to December 8th, December 29th, and January 18th, the per cent acid (of 1.10) is the same. The ratios are all so near 7 that for all practical purposes they might be taken, as 7. As to the first ratio, of 8.1, it clearly indicates that the fruit composing that sample must have been from an earlier bloom. This is supported by other data as well: as for sample, by its color, which was yellow, with only a green tinge, while all the samples immediately following were green, with only a tinge of yellow, and also its content of invert sugar and of sucrose, which are higher and lower respectively than those following. This sample, then, in all fairness, should not be compared with the rest of the table.

In tree N a ratio of more than 7 is established from the beginning, October 6th, and considerable fluctuation occurs.

Turning to the average of all the trees on different dates, (see table 15), and discarding the figure for September 22nd, as this is the ratio of the first sample of tree M just described (no other sample appears to have been picked on this date), we obtain a continued, uninterrupted increase in ratios, from 6.5 on October 3rd–6th up to 7.33 on November 21st. Hereafter all ratios show more than 7, but the increase is very slight and some fluctuation is noticed.

Color.—Again we find the green predominating, in spite of the fruit having reached a ratio of 7. It is only well towards the end of the season that the yellow becomes more prominent than the green. This again emphasizes the fact that grapefruit here does come up to a ratio of 7 early enough in its maturation period to justify the application of the standard to Porto Rico fruit. Usually the fruit which is quite near the neighborhood of 7 in ratio shows up more

green color than yellow, and when the yellow color predominates the ratio is generally in the neighborhood of 8.

This supports the view that the fruit comes to maturity when it has reached a ratio between 7 and 8, which is perhaps nearer 8 than 7. However, in the Marsh's Seedless maturity seems to come earlier than in the Duncan, judging from the fact that all signs of maturity, including color, appear earlier.

The lowest ratio of solids to acid (average of all trees) was 6.15 and occurred on October 3rd–6th, the highest was 7.507, which occurred on February 24th, and the average for the season was 7.08. These fruits reached the ratio of 7 pretty early in the season, but the ratios as a whole did not increase much beyond this point.

Per cent sugars.—Taking the averages of all trees for each one of the dates on which fruit was picked and arranging them in the ascending order of their corresponding ratios we obtain the following columns:

Ratio	Total sugars Per cent	Invert sugars Per cent	Cane sugars Per cent
6.15	4.97	2.77	2.08
6.74	4.32	2.52	1.48
6.86	4.73	3.01	1.60
	(4.575)	(2.766)	(1.72)
7.17	5.14	3.67	1.35
7.33	4.39	3.20	1.57
7.34	5.12	3.54	1.60
7.43	5.08	2.96	1.95
7.46	4.89	2.59	2.08
7.507	3.91	2.93	0.86
	(4.731)	(3.081)	(1.586)

The columns above the first line represent samples whose ratios were below 7, while those following are for samples whose ratios were above 7. The figures in parenthesis are averages.

The averages for total sugars have been calculated from those for invert sugar and sucrose.

As seen, the total sugars and the invert sugar show an increase, while the cane sugar, or sucrose, shows a decrease. The increase in total sugars, however, has been very slight, this demonstrating that the increase in invert sugars has been chiefly due to inversion. This statement is perfectly well proven by a simple calculation.

The difference between the averages for total sugars is 0.156 per cent. The difference between the averages of invert sugar is 0.315 per cent. Calculating the averages for cane sugar to their invert sugar equivalents we have 1.72 cane sugar equivalent to 1.809 invert sugar, and 1.586 cane sugar equivalent to 1.650 invert sugar. The

difference between these two invert sugar equivalents is 0.159. That is the cane sugar inverted is equivalent to 0.159 invert sugar. Out of a total increase of 0.315 per cent in invert sugar, 0.159 per cent has been due to inversion of sucrose.

The difference between the total increase in invert sugar, and the increase due to sucrose inversion ought to approximate the increase in total sugars. In this instance they are identical. Thus, the above referred to difference is 0.156 per cent (0.315 minus 0.159) and the difference in total sugars is, as noted above, 0.156. There is no question, then, as to the inversion of sucrose when the ratio of 7 is reached. This proves that the Marsh's Seedless reach maturity when a ratio of 7 is present. This makes the Marsh's Seedless reach maturity with a little lower ratio than the Duncans.

Summarizing the results obtained for Marsh's Seedless for this season we have:

1. The weight per fruit is rather constant for the ratios and sizes examined. Among the trees the average weights varied between 459 and 530, the average of all being 509.78 grams. The average sizes varied among the trees from 52 to 59 the average of all being 53. The average weight per box was 26.914 kgms., and showed a marked increase throughout the season. The trees varied among themselves from 25.387 to 31.001 kgms. per box.

2. The per cent skin was rather constant and high, the average of all trees for the season being 30.98 per cent. There was no uniformity among trees, the skin content varying from 24.31 per cent, the average for tree B to 35.57, the average for tree M.

3. A fair percentage of juice was shown, the average of all trees for the season being 44.94 per cent. The trees varied in their averages from 40.62 per cent (tree M) to 48.05 per cent (tree B). Toward the latter part of the season the fruit contained more juice than at the beginning, a notable increase being evident after November 21st.

4. The solids in solution are rather low, the average of all trees for the season being 7.91 per cent. The averages of the individual trees ranged from 7.24 per cent to 8.7 per cent. This item showed frequent fluctuations, and may be regarded as constant for the ratios under consideration.

5. The per cent acid showed a perceptible decline. The average for all the trees for the season was 1.117. The individual trees ranged from 1.054 to 1.155, thus showing a fair degree of uniformity.

6. The ratio of solids to acids increased, but at a slow rate. The rate of increase in this instance is considerably lower than in the Duncan fruit, and the ratios obtained lower also. The ratio of solids to acid of all trees for the season was 7.08 as against 7.23 for the Duncan. In no instance was a ratio of 8 obtained, the highest being 7.507. This fruit reached an approximate ratio of 7 almost at the same time as the Duncans, between November 3rd and 21st. The averages for the individual trees ranged between 6.69 and 7.91.

7. The total sugars, as well as the invert sugar were higher toward the latter part of the season, after November 21st. The sucrose was lower toward the end of the season. The averages were 4.825 total sugars, 3.079 invert sugar, and 1.658 sucrose. This gives the Marsh's Seedless a little less sugars than the Duncans. The ratio of invert sugar to sucrose is much higher for the Marsh's than for the Duncans, for the former being 3.857 and for the latter 1.448.

The averages for the individual trees showed a fairly good agreement in regard to these items as may be seen from table No. 16.

In substance—

1. The Marsh's Seedless fruit juice also contained during this season solids in solution in a proportion which was at least seven times the proportion of acid it contained at maturity.

2. This proportion of solids to acids came about some time during the latter part of November.

3. The changes undergone by this fruit were pretty nearly of the same nature as those undergone by the Duncan, only they differed in extent and rate at which they proceeded.

4. The fact that most of the changes noticed proceed regularly, or nearly so, until a ratio of more or less 7 is reached, and that the inversion of sucrose occurs after this ratio obtains, point to this ratio as marking the point of maturity of the fruit.

TRIUMPH GRAPEFRUIT, SEASON 1916–1917.

INDIVIDUAL TREE RECORDS.

Only two trees, located in two different groves, A and K, were used for this series of tests.

Below are given two tables showing the composition of the biweekly samples picked from each tree:

TABLES SHOWING BIWEEKLY ANALYSES—FRUITS FROM TWO DIFFERENT GROVES.

TABLE 17.

Analyses of Fruit (Triumph), Test Tree, Grove A, Pueblo Viejo.

Date picked	Average size	Average size	Color	Thickness of skin in inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (acid)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio invert sugar to sucrose
October 5	525	64	G. S. Y. T.	5/16	33.73	33,600	30.73	8.9	1.04	8.5	2.19	5.63	3.32	0.659
October 23	325	64	Y. G. T.	7/32	30.00	20,800	36.69	8.8	.94	9.3	2.44	5.63	3.07	0.794
November 3	460	80	Y. G. T.	1/4	26.99	36,800	35.40	9.5	.95	10.0	2 69	6.11	3.30	0.815
November 21	359	64	G. S. Y. T.	1/4	22.87	22,176	39.41	9 5	.95	10.0	3 50	6.11	1.49	2 349
December 8	484	64	Y. G. T.	1/4	31.52	30,976	36 14	9.3	.82	11.3	2.44	6.36	3.80	0.642
December 29	496	64	Y. G. T	1/4	28 57	31,744	31.69	9.5	.70	13.6	2.93	5.87	2.82	1.039
January 18	485	64	Y. S. G. T.	1/4	24.13	31.040	31.96	9 0	.76	11.8	3.10	5.14	1.92	1 614
February 9	491	54	G. Y.	1/4	30.93	26.914	29.66	9.5	.70	13.57	3.50	6.36	2.74	1.277
Averages for the season	453	64		1/4	28.38	29,356	33.96	9.25	0.857	10.79	2.847	5.7999	2.807	1.014

TABLE 18.

Analyses of Fruit (Triumph), Test Tree, Grove K, Pueblo Viejo.

Date picked	Average weight	Average size	Color	Thickness of skin inches	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar to sucrose
September 22	332	96	G. Y.	1/4	31.55	31,872	24.45	9.8	1.08	9.0	2.93	7.09	4.04	0.725
October 6	333	96	G. S. Y. T.	1/4	31.10	31,968	27.02	10.4	1.05	9.9	2.69	7.33	4.52	0.595
October 23	355	96	G. Y. T.	5/16	31.76	34.080	25.93	10.1	1.03	9.8	2.93	6.36	3.31	0.885
November 3	329	100	Y. G. T.	7/32	25.96	32,900	32.45	10.7	.90	11.6	2.93	6.84	3.79	0.773
November 21	290	100	G. S Y. T.	1/4	24.42	29,000	32.55	10.8	.88	12.2	3.67	7.09	3 30	1.112
December 9	316	120	G. Y. T.	1/4	25.07	37.920	37.00	10.4	.88	10.0	3.10	7.33	4.11	0.754
December 29	281	100	Y. G. T.	.....	22.22	28.200	40.00	11.0	.76	14.5	3.91	6.84	2.81	1.391
January 18	325	68	Y. S. G. T.	3/8	41.02	22,100	38.28	11.6	.76	15.1	3.91	7.81	3.78	1.034
Averages for the season	320	97		15/64	29.13	30.993	32.21	10.58	0.917	11.53	3.258	6.894	3.457	0.942

By averaging the results obtained for the samples picked on the same date, the following table to show the mean composition of the fruit on succeeding dates was constructed:

TABLE 19.

Showing Biweekly Analyses of Grapefruit from Two Different Groves.

TRIUMPH, SEASON 1916–1917.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acids	Ratio of solids to acids	Invert sugar	Cane sugar	Total sugar	Ratio invert to cane sugar
September 22...	332.	31.35	24.45	9.8	1.08	9.0	2.93	4.04	7.18	0.725
October 5-6...	429.	32.41	28.87	9.6	1.04	9.2	2.44	3.92	6.568	0.620
October 23...	340.	30.88	31.31	9.45	0.99	9.5	3.18	3.19	6.539	1.000
November 3...	394.5	26.47	33.92	10.10	0.92	10.9	2.81	3.54	6.537	0.790
November 21...	324.5	23.64	35.98	10.1	0.91	11.1	3.58	2.39	6.090	1.500
December 8...	400.	28.29	36.57	9 8	0.85	11.15	2.77	3.95	6.929	0.700
December 29...	388.5	25.39	35.84	10.3	0 73	14.1	3.42	2.81	6.379	1 210
January 18...	405.0	32 57	35.12	10.2	0.76	13.4	3.50	2 85	6.500	1.23
February 19...	491.	30.93	29.66	9.5	0.70	13.57	3.50	2.74	6.385	1.27
Average for the season.....	487.16	29.10	32.41	9.872	0.887	11.12	3.125	3.27	6.568	0.9556

On each of the dates noted samples of 12 fruits were picked from each of two trees and were separately analyzed. The averages of the samples collected on each separate date are presented above.

From the two previous tables, the following, showing the mean composition of the fruit from each tree, was abstracted:

TABLE 20.

Showing Mean Composition of Fruit for Each Tree for the Season.

TRIUMPH, SEASON 1916–1917.

Grove	Average weight	Average size	Per cent skin	Thickness of skin in inches	Per cent juice	Weight of fruit per box in Grm.	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar as invert	Cane sugar	Ratio of invert sugar sucrose
A	453	64	28.38	1/4	33.96	29.356	9.25	0.857	10.79	2.847	5.800	2 807	1.014
K	320	97	29.13	15/64	32.21	30,993	10.58	0 917	11 53	3.258	6.894	3.457	0.942

SEASONAL CHANGES, 1916–1917.

An examination of the tables will reveal some interesting differences between this variety and the other two already studied.

Two distinctly different sizes were chosen—the fruit picked from tree K, being small, of average size number 97, and the fruit from tree A, which was of medium size, average size number 64, more or less.

Eliminating the two samples not of size 64, in tree A, and comparing all the others, of size 64, as to weight, an increase in weight per fruit is noticed from October 23rd on.

On this same date a decline is noticed in acid, and with only one exception all samples thereafter show up more color.

The ratio increases continuously and practically without interruption, while the solids increase also almost continuosly after October 23rd, and the percentage of skin drops to a lower level on this date also and stays lower in all the succeeding samples except two.

There is a slight increase in total sugars, but no steady gains are evident, and the same might be said in regard to invert sugar, although in the latter the gain is more pronounced than in the former. The percentage of cane sugar decreases, although fluctuations are noticeable. The ratio of invert sugar to sucrose gains from the very beginning so that higher inversion is present from the start, or the formation of invert sugar proceeds at a faster rate than that of sucrose. The above data may suggest that this fruit came to full maturity some time around October 23rd.

In tree K the weights per fruit and per box show no regular increases or decreases. Fluctuations occur due to differences in sizes, but taking all in all this item may be conidered as fairly constant.

The percentage of acid shows small decreases from the beginning, but on November 3rd it drops considerably to a much lower level, and keeps on the decline to the very end.

The juice content also increases from the beginning, but a decided gain does not occur until November 3rd.

The ratio shows also a perceptible increase on November 3rd, while the color assumes a more yellowish hue (with one exception) after this date.

The total sugars may be regarded as tolerably constant, while the invert sugar shows a perceptible gain on November 21st and the cane sugar, with only one exception, is lower for the samples picked after this date. The ratio of invert sugar to sucrose is greater than unity for the first time on November 21st.

In the case of this tree the fruit probably came to full maturity some time between November 3rd and November 21st.

Both these tables again confirm the observation that the fruits with the higher percentage of juice exhibit a lower weight per fruit.

Turning now to the table of averages (No. 19) we find that on November 3rd the following observations may be made: The skin and the acid have decreased, while the juice, solids and ratio have increased. The cane sugar shows evident signs of inversion on November 21st. With few exceptions these lower and higher levels are respectively maintained on succeeding dates.

It will be noticed that all the changes which may be taken as marking the point of maturity of the fruit, occur in this variety somewhere near the same date as with the other varieties October 23rd to November 21st, but with a much higher ratio, usually in the neighborhood of 11. The writer is inclined to believe that this fruit does not reach maturity under local conditions with a ratio of 7, but with much higher one, only that its very low acid content makes it appear with a legal ratio of 7 quite early, before it really is mature.

It will thus be seen that this variety reaches the legal ratio of 7 very early in the season, but it is doubtful whether this means real maturity, at that early date.

It should be noticed that the per cent solids is much higher and the per cent acid much lower in this variety than in the other two, facts which account for the high ratio exhibited by this variety, which reaches limits to which the others do not even approach. This accounts for the staleness and lack of body of the juice, which is rather insipid. The fruits of this variety contain less juice than those of the other two. They contain more sugar and a closer ratio of invert sugar to sucrose, in many instances the sucrose being higher, a condition very rare in the other two varieties. The total average shows the proportion of the two sugars to be about equal, with the sucrose slightly higher.

Comparing the two trees selected among themselves, we find that although there is great difference in size and weight per fruit of the fruit picked from each one, yet they agree pretty closely in all other points of comparison.

CONCLUSIONS FOR THE SEASON 1916–1917.

The data for this season suggest that there are a number of changes in the appearance and composition of the fruit the direction, rate, or nature of which may serve to indicate the point of maturity of a grapefruit. These changes are, mainly, the color of

the fruit, the gain in juice, the reduction of the rind, the increase of the ratio of solids to acids in the juice, the increase of invert sugar, and the reduction of sucrose in the juice.

These changes occur to a greater or lesser extent in all three varieties, but the extent to which they occur and the rate at which they proceed seem to differ for each variety.

Based on the changes noted above, the conclusion is possible that a grapefruit, no matter of which one of the three varieties tested, when matured, always presents a ratio of solids to acids in solution in its juice of at least 7. The "Triumph" variety under our local conditions comes to maturity with a ratio of solids to acids much higher than 7, and probably between 10 and 11. All three varieties came to maturity some time during the month of November, but the "Triumph" reached the legal ratio of 7 much earlier in the season, as the first sample picked on September 22 already had a ratio of solids to acid equal to nine.

SEASONAL CHANGES, SEASON 1917 TO 1918.

For this season's work ten trees were selected in ten different groves, which included some of the groves of the previous year, and some new ones. Of the ten trees selected, seven were of the Duncan variety and three of the Marsh's Seedless variety. The trees were designated this time by numbers instead of letters. No analysis of soils or determination of sugars were conducted during this season, for lack of help.

The places in which trees were selected and the type of soil in which each tree stood were as follows:

Tree No.	Owner or Manager of grove	Location	Type of soil
	DUNCAN		
2	Mr. Newton	Bayamón	Clay
3	Mr. L. W. Davis	Vega Alta	Clay
4	Mr. E. D. Stevens	Vega Alta	Sand
6	Mr. M. L. David	Vega Alta	Clay loam
8	Mr. W. K. Kaehrle	Vega Alta	Sand
10	Mr. R. L. Mills	Pueblo Viejo	Clay
11	Mr. Guildermeister	Pueblo Viejo	Sand
	MARSH'S SEEDLESS TREES		
5	Mr. E. D. Stevens	Vega Alta	Sand
7	Mr. W. K. Kaehrle	Vega Alta	Sand
9	Mr. Stanwood		

INDIVIDUAL TREE RECORDS.

DUNCAN.

The results obtained for each tree are given below in tabular form.

TABLE 21.

Individual Tree Records.

SEASON 1917–1918.

Each of these tables was constructed as follows: Ten fruit were picked from the tree to which the table refers on each of the dates noted. This fruit was immediately analyzed, and the results tabulated as herein shown.

TREE No. 2—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	614.25	1/4	22.11	43.07	8.50	1.028	8.2	46	28,255
October 4	635 55	1/4	22.30	41.60	8.5	1.017	8.3	41	26,050
October 25	691.59	1/4	26.22	40.98	8.67	1.036	8.36	42	29 046
November 1	670.25	1/4	21.66	33.33	8.60	1.000	8.60	42	28.570
December 10	667.00	1/4	25.90	43.10	8.65	1.000	8.65	36	24,012
January 17	552 00	3/16	25.00	43.00	8.20	0.933	8 80	57	31.464
Averages for the season.....	645.07	1/4	23.86	40.84	8.52	1.002	8.50	44	27,900

TABLE 22.

TREE No. 3—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 22	576.5	1/4	25.6	42.60	9.15	1.313	6.96	48	27,672
October 4	586.16	1/4	26.0	38.55	9.15	1.242	7.36	?	....
October 25	.....	.....	.....	.....	.....	.....	.....	.....	.....
November 12	646.23	1/4	21.66	31.57	8.7	1.017	8.55	48	31.019
December 10	586	1/4	23.5	44.0	8.45	0.94	8.90	49	28,714
January 17	552	3/16	25.0	43.0	8.22	0.93	8.80	57	31.454
Averages for the season.....	589.38	1/4	24.35	39.94	8.734	1.088	8.03	40.4	29,717

TABLE 23.

Individual Tree Records—Continued.

SEASON 1917–1918.

TREE No. 4—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Average size	Weight per box in grams
September 21	510.3	7/32	24.2	47.2	8.5	1.328	6.4	56	28,576
October 4	576.32	1/4	21.90	40.16	8.75	0.939	9.31	54	31,121
October 25	546.23	7/32	22.41	40.00	8.82	0.987	8.97	57	31,135
November 12	623.56	7/32	20.00	40.00	8.9	0.850	10.47	49	30,554
December 10	618	5/16	22.00	40.90	9.10	0.840	9.20	42	25,976
January 17	.....	.....	.....	.....	.....	.....	.....	.....	.....
Averages for the season.....	574.88	7/32	22.10	41.65	8.814	0.9888	8.91	51.60	29,472

TABLE 24.

TREE No. 6—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	491.8	5/16	28.86	33.17	9.61	1.718	5.59	59.	29,016
October 4	466.19	1/4	25.06	58.70	9.93	1.310	7.58	64.	29,826
October 25	424.29	1/4	15.55	37.77	9.85	1.311	7.51	72.	30,549
November 12	476.17	9/32	26.19	33.33	9.60	1.090	8.80	64.	30,475
December 10	391.00	1/4	25.00	31.00	9.80	1.350	7.26	74.	28,934
January 17	.....	.....	.....	.....	.....	.....	.....	.....	.....
Averages for the season.....	449.89	1/4	24.12	38.79	9.76	1.356	7.19	66.6	29,762

TABLE 25.

TREE No. 8—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	463.05	1/4	28.82	40 81	10.08	1.575	6.40	54	25,004
October 4	566.80	1/4	22 50	41.66	9,98	1.427	6.29	54	30,607
October 25	736.93	11/32	29,23	32.30	9.20	1.478	6.22	40	29,477
November 12	634.90	9/32	23.21	32 14	9.50	1.496	6.35	48	30,475
December 10	680.00	5/16	21.70	39.00	9 65	1.330	7.25	42	28,560
January 17	713.00	9/32	25.00	38.00	9.55	1.190	8.00	39	27,807
Averages for the season.....	632.45	9/32	25.07	37.32	9.49	1.416	6.70	45.8	28,654

TABLE 26.

Individual Tree Records—Continued.

SEASON 1917–1918.

TREE No. 10—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21									
October 4	523.90	1/4	24.50	43.20	10.60	1.690	6.27	59	39,940
October 25	408 00	7/32	25.00	33.33	10.55	1.662	6.34	72	20,376
November 12	476.17	1/4	23.80	33.33	10.80	1.518	7.11	67	31,903
December 10	575.00	1/4	24.00	44.00	10.40	1.370	7.59	48	27,600
January 17	552.00	1/4	27.00	41.00	11.10	1.550	7.16	57	31,464
Averages for the season.....	507.01	1/4	24.86	38.09	10.69	1.558	6.86	50.6	30,256

TABLE 27.

TREE No. 11—DUNCAN.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per cent in grams
September									
October 4	585.77	5/16	26.60	33.80	8.80	1.287	6.83	54	31,631
October 25	555.54	3/8	18.36	44.90	8.65	1.434	6.03	52	28,888
November 12	566.87	5/16	26.00	29.00	9.00	1.500	6.00	54	30,610
December 10	580.00	5/16	32.00	39.00	8.90	1.260	7.06	44	25,520
January 17	563.00	9/32	28.00	34.70	8.75	1.250	7.00	51	28,713
Averages for the season.....	570.24	5/16	26.19	24.88	8.82	1.346	6.55	51	29,072

In the table below the results presented were obtained by finding the averages of the analyses of all samples picked on the same date, for the dates noted. Ten to twelve fruits were picked from each tree.

TABLE 28.

Showing Biweekly Analyses of Duncan Grapefruit.

Sampled from seven different trees, and analyzed immediately after picking.

SEASON 1917–1918—DUNCAN.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids in juice	Per cent (citric) acid	Ratio of solids to acids
September 21	548.21	25.18	41.51	8.94	1.347	7.280
October 4	562.92	24.12	42.52	9.24	1.273	7.420
October 25	560.43	22.79	38.21	9.29	1.318	7.288
November 12-17	586.30	23.13	32.24	9.30	1.210	7.98
December 10	585.28	24.87	44.14	9.28	1.355	7.998
January 17	595.00	26.25	39.17	9.40	1.230	7.740
Averages for the season	573.02	24.39	38.97	9.24	1.2555	7.36

The averages for each tree for the season may be seen in the table that follows:

TABLE 29.

Showing Mean Composition of Fruit for Each Individual Tree for the Season.

DUNCAN—SEASON 1917–1918.

Tree No.	Average weight per fruit in grams	Average size	Thickness of skin in inches	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids in acid
2	645.0	44	1/4	23.86	27,900	40.84	8.520	1.002	8.50
3	589.4	40	1/4	24.65	29,717	39.94	8.734	1.088	8.03
4	574.88	51	7/32	22.10	29,472	41.65	8.814	0.988	8.91
6	449.89	66	1/4	24.12	29,762	38.79	9.760	1.356	7.19
8	632.45	46	9/32	25.07	28,654	37.32	9.49	1.416	6.70
10	507.00	50	1/4	24.86	30,256	38.97	10.61	1 558	6.86
11	570.24	51	5/16	26.19	29,072	34.88	8.82	1.346	6 55

SEASON 1917 TO 1918.

DUNCAN.

Size.—The size of the fruit has been mostly in the neighborhood of 46 and 54. Of 44 samples measured 19 ran from 40 to 49, while 16 varied between 51 and 59. This coincides with the observations made during the season 1916 to 1917. There is no definite connection shown between the time of picking and the size of the fruit. This may be due to the mixture of fruits from different blooms on the trees, and the practical impossibility of being absolutely sure

that every fruit picked on successive dates came from the very same bloom.

Weight.—Of the seven trees tested during this season, in four of them, trees Nos. 2, 3, 4 and 8, the weight of the fruit has increased throughout the season, while in the remaining four a decrease has been noticed.

As regards the relation previously noted between weight of fruit and per cent juice, it is very difficult to establish any comparison, due to the great variation in the sizes of the samples obtained. But if we compare samples of approximate sizes from the same trees, the same relation, with a few exceptions, is found to exist.

In tree No. 2, taking the first four samples in the table, we find the percentage of juice decreasing from September to November, and the average weight per fruit increasing in the same order. Again, in tree No. 3, taking the samples corresponding to September 22nd and November 12th and December 10th, we find that the sample for November 12th, with the lowest per cent of juice, 31.57 per cent, shows the highest weight per fruit, 646 grams.

The same is evidenced by the three first samples of tree No. 4 and the samples for October 25th, and November 12th of tree No. 11.

Per cent juice.—Contrary to last season's results, the per cent juice this year has not shown any tendency to increase, but has rather exhibited fluctuations pointing to a decrease, although in many instances a gain was made toward the last of the season. This is shown not only by the tables for individual trees, but also by the table of averages, No. 28. This may be due to the fact that the fruit matured rather early this season.

The average for all the trees for the whole season was 38.97 per cent, lower than last year, which was 43.57 per cent.

Per cent skin.—In four cases, trees Nos. 3, 4, 6 and 8, the per cent skin showed a tendency to decrease, while in two cases it remained practically constant, and in one increased. This decrease in the per cent skin is also noticed in the table of averages.

Thickness of skin.—An examination of the tables of individual trees shows that this item is practically constant through the season. This is a sign that the fruit were already fully developed when the first sample was picked.

Per cent solids in juice.—The records for the individual trees show this factor to be practically constant through the season. In two cases, trees Nos. 4 and 6, a small, but perceptible increase is

noticed. In trees Nos. 2, 10, and 11, increases in the hundredths were noticed, so that they may be regarded as showing constancy. In the other two trees slight decreases were manifested. However, the table of averages for all the trees (No. 28) shows a small but marked increase as the season advances. This coincides exactly with previous observations. The average for all the trees for the whole season was 9.24 per cent, higher than last season's.

Notice that the solids are higher and the per cent juice lower for this season than for last.

Per cent acid.—In all cases except one, tree No. 11, the per cent acid has decreased as the season advanced. This is also shown by the table of averages. The lowest average shown by all the trees was 1.155 on December 10th, and the highest 1.347 on September 21st. The average of all the trees for the whole season was 1.255. This makes the acid content of the Duncans practically the same as for last season, when the minimum average shown by all the trees was 1.11 on December 29th, the highest 1.36 on September 25th, and the average of all the trees for the whole season 1.205.

The observations of this year in this respects coincide with those for last.

Ratio of solids to acids.—An examination of the tables will show a steady gain in most instances. In only one instance, tree No. 2, was the ratio from the beginning higher than 7, and even here, a slight, but steady gain was observed. The fruit from this tree started with a ratio of 8.2 on September 21st, and gradually and uninterruptedly climbed up to 8.80 on January 17. It should be noticed, however, that the rate of increase is very slow. In all other instances the fruit started with ratios lower than 7, even as low as 5.59, as in tree No. 6, and ended with ratios higher than 7, even as high as 9.20 as in tree No. 4, which started with a ratio of 6.4. This increase is shown by the table of averages, although not so clearly as by the individual trees.

Taking the averages for all the trees on different dates we find the lowest average ratio occuring on October 25th, which was 7.238, and the highest on December 10th, which was 7.998. The average ratio of all the trees for the whole season was 7.36. This is slightly higher than the average ratio for 1916 to 1917, which was 7.23. In this season all the averages given for the different dates, beginning September 21st, are higher than 7, while the corresponding averages for 1916–17 are lower than 7 for the first three pickings, namely, September 25th, October 6th, and October 24th.

During the season 1917 to 1918, then, we have less juice in the fruit, more solids, practically the same acid, and very slightly higher ratios than during 1916 to 1917. The weight per fruit was higher in the previous season.

The mean composition of the Duncan fruit for the two seasons surveyed has been as follows:

Season	Weight per fruit in grams	Percent skin	Percent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
1916-17.....	602	28.25	43.57	8.70	1.203	7.23
1917-18.....	573	24.29	38.97	9.24	1.255	7.35

In a general way, the nature of the changes observed during this season has been the same as last, although there have been some differences as to the extent of the changes. This may be due to meteorological conditions, as well as to the fact that the trees used were not in every instance the same as those used last season. However, this last supposition is disproved by the facts if we compare the records for both seasons of only those trees that were continuously tested from 1916 to 1918. Following is a comparison. The trees were designated during the season 1916–17 by letters and during 1917-18 by numbers. The equivalences are as follows:

Grove	Designation during 1916-17	Designation during 1917-18
Mr. Newton	I	2
Mr. E. D. Stevens.....	N	4
Mr. M. L. David	B	6

As seen, then, tree I and tree No. 2 are the same; so are tree N and tree No. 4, and tree B and tree No. 6.

Their records compare as follows:

Tree No.	Weight per fruit	Thickness of skin	Percent skin	Percent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
Tree I	657	5/16	27.59	42.51	8.64	1.124	7.69
No. 2.....	645	1/4	23.86	40.84	8.52	1.002	8.60
Tree N.....	471.6	1/4	27.99	42.77	8.62	1.166	7.39
No. 4.....	575	7/32	22.10	41.66	8.81	0.089	8.91
Tree B.....	450.8	1/4	27.10	45.74	8.46	1.252	6.76
No. 6.....	449.9	1/4	24.12	38.79	8.76	1.356	7.18
Averages for 1916-17.....	526.6	7/32	27.56	43.64	8.56	1.514	7.28
Averages for 1917-18.....	556.6	1/4	23.36	40.42	8.86	1.115	8.86

The very same trees, then, showed a record in 1917–18 different from that of 1916 to 1917, and the differences noted are of the same order as those found among the averages of all trees tested for the two seasons.

The changes undergone by Duncan fruit during this season, are much less pronounced than during season 1916–1917; in fact, some of them are totally absent, as no regularity in the variations have been detected. Only the slight decrease in acidity of the juice and a corresponding increase in the ratio of solids to acids have been at all regular.

To account for this lack of uniformity in behavior, reference must be made to the fact that the fruit showed a ratio of over 7 with the first sample picked on September 21st. It was observed the previous season, that when maturity was reached, the progressive changes in the fruit ceased to be regular, and fluctuations due to individual variations were apparent. The data on inversion of sucrose which, as was seen, exhibited regularity precisely after maturity are not available to judge the behavior of the fruit during this season, but with the data at hand we are safe in assuming that this fruit was ripe already when the first sample was picked, so that the changes which make for maturity had already taken place, at least, to a very large extent.

As will be seen further on, this early maturity may be ascribed to a reduction in the rainfall, which also accounts for the lower juice content and higher solids in juice found in this season's fruit.

Again, the fruit exhibited a ratio of over 7 when matured. Both maturity and ratio were reached very early this season. Most of the trees had matured fruits in October.

SEASONAL CHANGES, 1917–1918.

MARSH'S SEEDLESS.

Only three trees of this variety were tested during this season, trees Nos. 5, 7, and 9. The composition of their fruit was found to be a follows:

TABLE 30.

Individual Tree Records.

SEASON 1917–1918.

TREE No. 5—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Average size	Weight per box in grams
September 21	444.15	5/16	26.85	42.55	7.81	1.137	6.880	64	28,425
October 4	412.27	1/4	25.00	45.00	7.93	1.121	7.00	72	29,683
October 25	510.18	5/16	26.66	42.26	7.63	0.963	7 92	61	30,121
November 12	532.86	5/16	25.53	38.33	7.30	0.876	8.33	57	30.378
December 10	506.00	1/4	27.00	47.00	7.20	0.880	8.19	62	31,372
January 17	.....	.....	.....	.....	.....	.....	.....	.....	.....
Averages for the season	481.09	9/32	26.21	43.01	7.57	0.995	7.60	63	20,994

TABLE 31.

TREE No. 7—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skid	Per cent skin	Per cent juice	Per cent solid	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 21	652.05	5/16	28.90	38.4	9.26	1.452	6.37	46	29,994
October 4	.....	.....	.....	.....	.....	.....	.....	.....	.....
October 25	555.54	9/32	24.48	32.65	10.00	1.541	6.48	59	22,777
November 12	538.86	1/4	23.40	30.00	9.80	1.475	6.64	60	32 331
December 10	609.00	5/16	28.00	36.00	9.90	1.350	7.33	46	28,014
January 17	644.00	1/4	27.00	42.00	9.70	1.28	7.60	48	30,912
Averages for the season	599.89	9/32	26.36	35.81	9.73	1.419	6.85	51.8	28,805

TABLE 32.

TREE No. 9—MARSH'S SEEDLESS.

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Weight per box in grams
September 23	421.2	5/16	28.84	46.15	8.20	1.325	6.18	68	28,641
October 4	415.70	1/4	26.30	47.72	8.20	1.315	6 23	64	26,605
October 25	.....	.....	.....	.....	.....	.....	.....	.....	.....
November 12	464.84	5/16	26.82	41.46	8.10	1.097	7.38	64	29,749
December 10	483.00	5/16	33.33	45.00	7.70	1 050	7.31	60	28,980
Averages for the season	446.18	9/32	28.82	45.08	8.05	1.197	6.72	64	28,493

TABLE 33.

Showing Biweekly Analyses of Fruit Picked from Three Different Groves.

On each one of the dates noted 12 fruits were picked from each of three trees set aside in three different groves, and the samples thus collected were separately analyzed. The results of the samples picked on the same date were averaged, and the averages are tabulated below.

SEASON 1917–1918—MARSH'S SEEDLESS.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Average weight per box
September 21-23	495.11	28.35	41.97	8.83	1.372	6.43	46	22,775
October 4	413.98	25.65	46.36	8.06	1.318	6.61	68	28,151
October 25	532.86	25.57	37.44	8.81	1.252	7.03	60	31,972
November 12-17	512.18	25.25	36.58	8.40	1.149	7.31	60	30,731
December 10	532.50	29.44	42.66	8.26	1.093	7.55	56	29,820
January 10	644.00	27.00	42.00	9.70	1.280	7.60	48	30,912
Averages for the season	521.78	26.87	41.16	8.67	1.227	7.09	56	29,219

TABLE 34.

Showing Mean Composition of Fruit from Each Individual Tree for the Season.

SEASON 1917–1918—MARSH'S SEEDLESS.

Tree No.	Average weight per fruit in grams	Average size	Thickness of skin	Per cent skin	Weight of fruit per box	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid
5	481.00	63	9/32	26.21	29,994	43.01	7.57	0.9954	7.60
7	599.89	52	9/32	26.36	28,805	35.81	9.73	1.419	6.85
9	446.18	64	9/32	28.82	28,493	45 08	8.05	1.197	6.72

Weight and size.—Both variable. There is a tendency to increase on the part of the former, while the latter may be considered as practically constant. The increase in weight is shown by the weight per fruit in the tables for individual trees, and by the weights per box given in the table averages. (See tables 33 and 34.)

There are only two instances where a comparison can be made between the weight of fruits of the same size, viz, among the samples picked from tree No. 9 on October 4th and November 12th (see table No. 32), and between the samples obtained on September 21st and December 10th from tree No. 7 (see table No. 31).

In the first instance the fruit with the higher juice content weighed less, while in the second the opposite was true.

Per cent juice.—During this season there has been considerable fluctuations in the per cent juice. If in tree No. 5 (see table No. 30) we compare the per cent juice for fruit with a ratio of less than 7 with that of fruits with ratios between 7 and 8 and fruits with ratios above 8, we find the juice practically constant. In tree No. 7, however (see table No. 31), the fruits with a ratio of 7 or more have a higher juice content than the fruits with ratios below 7, but the reverse is true of tree No. 9, where the fruits with ratios below 7 have the higher per cent of juice. The table of averages for this season, No. 33, shows also a higher content of juice for the fruits with ratios below 7. This may suggest that the Marsh's Seedless begin to attain maturity when they have a ratio of less than 7.

Average of all trees for the season, 41.16 per cent. Highest average, 46.36 per cent, on October 4; lowest, 36.58, on November 12–17.

Per cent skin.—It has not been possible to trace any consistent change in a fixed direction during this season. There has been much fluctuation, and the factor may be considered as practically constant for this fruit within the ratios observed. This is shown both by the individual tree records and by the table of averages for this season.

Per cent solids in juice.—This item may be considered as constant for this season within the ratios observed. A mere inspection of the tables will convey this impression. The average for each tree differs very little from the first figure obtained for the season, and in fact, from any other figure in the table. The same is true of the table of averages as the percentages obtained in each case on different dates for a given tree lie as close together as could be expected within the circumstances. Of course, there are notable differences among individual trees. So the average for the season for tree No. 5 was 7.57 per cent, for tree No. 7, 9.73 per cent, and for tree No. 9, 8.05 per cent.

The average of all trees for the whole season was 8.67 per cent. The highest average of all trees for any one date was 9.70 on January 10th, and the lowest 8.06 on October 4. Among individual trees the highest per cent obtained was 10.0 per cent for tree No. 7 on October 25th, and the lowest 7.20 per cent for tree No. 5 on December 10th.

Per cent acid.—There is an uninterrupted, notable decrease in acid content all through the season. However, the decrease is much more rapid after a ratio of 7 is approximately reached. The decline really starts when a ratio of 6.5, more or less, is obtained, somewhere around October 25th.

In tree No. 5 the notable decrease occurs on October 25th with a ratio of 7.92. In tree No. 7 the first decline comes after October 25th, with a ratio of 6.64. In tree No. 9 there is a very slight decrease on October 4th, with a ratio of 6.23. The sample for October 25th, was missed, and the next sample picked, on November 12th, shows a notable decrease with a ratio of 7.38. It is not going beyond the limits of a reasonable possibility to suppose that on October 25th a perceptible decrease in acid should have been noticed in this sample.

In the table of averages for all the trees, the decline becomes constant after November 12th–17th, although the samples for October 4th and October 25th, were lower than the first. However, the latter, with a ratio of 7.03, was higher in acid than the former, with a ratio of 6.61.

The average acid content for all the trees throughout the season, was 1.227. The highest average for all the trees at any date was 1.372 on September 21st–23rd, and the lowest, 1.093 on December 10th.

These per cents are higher than those for the same fruit last season, and the average for the season is practically the same as those obtained for the Duncan fruit for the season 1916–17, and 1917–18.

Among individual trees the lowest per cent found was 0.86 on fruit from tree No. 5 on December 10th, and the highest, 1.541, in the sample picked from tree No. 7 on October 25th.

Ratio of solids to acid.—The ratio has increased all through the season, but rather slowly. Two trees failed to make an average of 7 for the season. The ratios very rarely went beyond 7. The one tree which reached an average of 7 did not reach 8. Taking the table of averages of all trees for the season, the first average ratio of 7 appeared on October 25th, just about the date when the decline in acid content started. By the end of the season, on January 10th, the ratio attained the highest average for the season, which was only 7.60.

CONCLUSIONS.

The changes undergone by the Marsh's Seedless grapefruit during this season were much less perceptible than last season's and in many instances were totally absent. As the changes in juice content, per cent skin, weight of fruit, and ratio of solids to acid take place with more intensity while the fruit is yet unripe and is progressing

toward maturity, it is safe to assume that the fruit in this season was very near maturity when the first samples were picked. If this is coupled with the fact that the characteristic decline in acid occurred this season with this fruit when the ratio was about 6.5, and notice is taken of the first average ratio of the season, which was 6.43, it will be seen that there is ample room for the assumption expressed above, and further, to suggest that this variety of grapefruit is capable of reaching maturity with a ratio of less than 7, but quite above 6.

Comparing now the averages for the two seasons, we make the same observations as in the case of the Duncans; that is, the fruit for the season 1917–18 has less juice, more solids, rather higher acid, and practically equal ratio. The sizes are about the same. This was so in the case of the Duncans, as well. The weight per fruit in the case of the Marsh's Seedless, though, was practically the same, only very little higher for the 1917–18 fruit. The figures are presented below.

Season	Weight per fruit	Per cent skin	Thickness of skin	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Average size
1916-17	509.8	30.88	25/64"	44.94	7.91	1.117	7.08	53
1917-18	511.8	26.87	.....	41.16	8.67	1.227	7.09	56

This is indicative of the fact that some fixed cause was acting to produce identical results, and the only one factor in this case that could affect all the trees in approximately the same way was the weather, as this was the only one that was very nearly the same for all of the trees in a given season.

SEASONAL CHANGES OF GRAPEFRUIT, 1918 TO 1919.

As already stated, only Duncan fruit was used during this season. As explained observations were made on the color of the skin, the taste of the juice, and the consistency of the cells. The same system of notation for color as that employed by Mr. Cady was adopted. For describing the taste, the term "tart" as used by Collison[1] was employed, for designating that particular taste which is neither entirely sour nor sweet but which is rather a kind of middle point between these two extremes. Then the words "sour" and "bitter" variously modified have been made to express obvious variations in taste. The juice cells have been described as "well filled" when

[1] Bul. 115, University of Florida Agricultural Experiment Station, "Sugar and Acid in Oranges and Grapefruit," by S. E. Collison.

they have been full of juice, turgescent, well rounded up, and with an even, glossy surface. When this condition has been present, but not to perfection, the terms "filled" and "partially filled" have been employed. In the absence of these properties the terms "dry" and "hard" have been used to describe them.

It was during this season that determinations of nitrogen, phosphoric acid, potash, and ash were made on the whole fruit. However, these data will be given and discussed in a separate section of this work.

Analyses of samples of soil and subsoil taken from around the bese of each tree were again made, and the results are given below.

The trees were again designated by numbers, following the numerical order of the previous year.

TREES SELECTED FOR THIS SEASON'S WORK.

All trees selected were of the Duncan variety, except tree No. 13, which was a Marsh's Seedless.

Manager or owner of grove	No. of the trees	Location	Type of soil
Mr. E. D. Stevens	12	Vega Alta	Sandy
Mr. E. D. Stevens	13	Vega Alta	Sandy
Mr. M. L. David	14	Vega Baja	Sandy loam
Mrs. C. D. Smith	15	Vega Baja	Sandy loam
Mr. E. R. Day	16	Manati	Clay loam
Messrs. Scoville and Castle	17	Manati	Clay loam
Mr. W. K. Kæhrle	18	Vega Alta	Sandy

COMPOSITION OF THE SOIL.

The analyses of the soils and the corresponding subsoils in each grove are given below—on their water-free basis.

Mr. Stevens' Grove—Trees Nos. 12 and 13.

	Soil	Subsoil
Color	Dark brown	Yellowish brown
Type	Sandy	Sandy loam
Depth of soil	Two feet	
Depth of subsoil sampled		Two feet
Moisture	1.24 per cent	1.50 per cent
Voatile matter	5.34 per cent	5.00 per cent
Insoluble matter	88.68 per cent	81.51 per cent
Nitrogen (N)	0.420 per cent	0.140 per cent
Phosphoric anhydride (P_2O_5)	9.102 per cent	Traces
Calcium oxido (CaO)	None	None
Iron and aluminium as (Fe_2O_3)	5.54 per cent	7.03 per cent
Potash (K_2O)	Traces	Traces

Mr. H. L. David's Grove—Tree No. 14.

	Soil	Subsoil
Color	Reddish brown	Red
Type	Sandy loam	Sandy clay
Depth of soil	Two feet	None
Depth of subsoil sampled		Eighteen inches
Moisture	1.64 per cent	1.46 per cent
Volatile matter	5.61 per cent	6.47 per cent
Insoluble matter	83.48 per cent	81.79 per cent
Nitrogen (N)	0.106 per cent	0.078 per cent
Phosphoric anydride (P_2O_5)	0.114 per cent	0.090 per cent
Calcium oxide (CaO)	Traces	None
Iron and aluminium oxide as (Fe_2O_3)	8.26 per cent	7.19 per cent
Potash (K_2O)	0.0014 per cent	0.003 per cent

Mrs. C. D. Smith's Grove—Tree No. 15.

	Soil	Subsoil
Color	Light brown	Red
Type	Sandy loam	Clay
Depth of soil	Nine inches	
Depth of subsoil sampled		Fifteen inches
Moisture	1.30 per cent	1.70 per cent
Volatile matter	6.26 per cent	8.77 per cent
Insoluble matter	83.59 per cent	78.59 per cent
Nitrogen (N)	0.112 per cent	0.089 per cent
Phosphoric anhydride (P_2O_5)	0.109 per cent	0.106 per cent
Calcium oxide (CaO)		
Iron and aluminium oxides as (Fe_2O_3)	6.52 per cent	9.80 per cent
Potash (K_2O)	00.027 per cent	0.055 per cent

Mr. E. R. Day's Grove—Tree No. 16.

	Soil	Subsoil
Color	Red	Red
Type	Clay	Clay
Depth of soil	Eigh inches	
Depth of subsoil sampled		Twelve inches
Moisture	2.32 per cent	2.90 per cent
Volatile matter	11.81 per cent	9.47 per cent
Insoluble matter	66.09 per cent	67.52 per cent
Nitrogen (N)	0.189 per cent	0.157 per cent
Phosphoric andydride (P_2O_5)	0.180 per cent	0.114 per cent
Calcium oxide (CaO)	0.221 per cent	Traces
Iron and aluminium oxides (as F e_2O_3)	14.26 per cent	22.99 per cent
Potash (K_2O)	0.043 per cent	0.007 per cent

Messrs. Scoville & Castle's Grove—Tree No. 17.

	Soil	Subsoil
Color	Reddish brown	Red
Type	Clay loam	Clay loam
Depth of soil	Ten inches	
Depth of subsoil sampled		Ten inches
Moisture	1.94 per cent	2.13 per cent
Volatile matter	10.12 per cent	8.03 per cent
Insoluble matter	72.92 per cent	71.32 per cent
Nitrogen (N)	0.195 per cent	0.134 per cent
Phosphoric anhydride (P_2O_5)	0.160 per cent	0.147 per cent
Calcium oxide (CaO)	0.235 per cent	0.221 per cent
Iron and aluminium oxides (as F e_2O_3)	11.47 per cent	12.00 per cent
Potash (K_2O)	0.025 per cent	0.01 per cent

Mr. W. K. Kaehrle's Grove—Tree No. 18.

	Soil	Subsoil
Color	Dark brown	Red
Type	Sandy	Sandy loam
Depth of soil	Six inches	
Depth of subsoil sampled		Eighteen inches
Moisture	1.15 per cent	1.14 per cent
Volatile matter	5.81 per cent	5.42 per cent
Insoluble matter	87.95 per cent	84.56 per cent
Nitrogen (N)	0.189 per cent	0.134 per cent
Phosphoric anhydride (P_2O_5)	0.134 per cent	0.150 per cent
Calcium oxide (CaO)	0.188 per cent	0.124 per cent
Iron and aluminium oxides (as Fe_2O_3)	3.79 per cent	6.40 per cent
Potash (K_2O)	0.085 per cent	0.053 per cent

These samples were taken with a gage of 4" diameter.

Physically and chemically we have here two distinct types of soils, as may be seen from the following comparative table, in which the numbers of the trees have been used to differentiate the groves on which they stand.

Tree No.	Insoluble matter	Nitrogen	Phosphoric acid	Potash	Calcium oxide	Ferric oxide	Color
12 and 13	88.68	0.420	0.100	Traces	None	5.54	Brown
14	83.48	0.106	0.114	0.0014	Traces	8.26	Red
15	83.59	0.112	0.109	0.027	None	6.52	Brown
18	87.95	0.189	0.134	0.085	0.18	3.79	Brown
16	66.09	0.189	0.180	0.043	0.22	14.26	Red
17	72.92	0.195	0.16	0.026	0.23	11.47	Red

From the physical point of view, the first four samples are of the same kind, sandy soils, while the last two are clay soils. All except one of the sandy soils are of brown color, while the two clay soils are red.

Chemically, we have a group of soils (which composes all of the sandy soils, except the one corresponding to tree No. 18) which are rather deficient in plant nutrition, and another group, composed of the clay soils plus the sandy soil corresponding to tree No. 18, which are soils of a fair degree of fertility. Moreover, the composition of the different soils in each group agree fairly well if differences of minor importance are waived, so that we can simplify matters by assuming that we have only two kinds of soils to deal with. It is well to keep these facts in mind when we come to discuss the effect of the soil on the composition of the fruit.

COMPOSITION OF THE FRUIT.

INDIVIDUAL TREE RECORDS.

The seasonal changes undergone by the fruit on each tree is shown by the tables that follow:

TABLE 35.

Individual Tree Records.

SEASON 1918–1919.

TREE No. 12—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	575.04	11/32"	26.53	30.82	8.94	1.151	7.767	54	.....	.....	.....	.....	G. Y. T.....	Tart.	Well filled
November 12	636.29	4/16"	23.59	43.82	8.26	1.065	8.260	34-46	4.030	4.371	8.63	0.921	Y. G.	"	" "
November 26	541.47	4/17"	24.59	44.10	9.10	1.015	8.965	54	1.977	2.749	5.867	0.719	G. Y.	"	" "
December 12	589.67	9/32"	24.88	47 00	8.80	1.018	8.64	46-64	3.220	3 190	6.58	1.009	Y.	"	" "
January 2	555.66	3/16"	22.36	32,88	9 00	0.9537	10.32	46-54	3.410	2.213	5.94	1.540	G. Y.....	"	" "
January 20	596.75	4/16"	24.78	41.73	8.70	0.941	9.24	46	3.480	2.110	5.58	1·649	G. Y.....	"	" "
February 24	595.35	4/16"	24.13	46.428	8.80	0.837	10.51	51	3.970	2.04	6.118	1.946	.....	"	" "
Averages for the season	584.77	1/4	24.41	40.97	8.80	0.9972	8.82	49	3.3478	2.382	5.854	1.405			

TABLE 36.

TREE No. 14—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent juice	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency
October 28	401.75	3/16	25.15	48.00	11.70	1.434	8.15	68	3.818	.....	.....	.....	G. Y. T.....	.....	Well filled
November 12	317.4	7/32	23.88	43.21	10.5	1.424	7 37	69	5.10	4.895	10.25	1.063	Y.	Tart	" "
November 26	354.36	3/16	24.22	39.50	10.3	1.327	7.76	80	2 244	2.671	5,057	0.840	S. Y.....	.....	" "
December 12	400.92	4/16	32.07	42 26	10.6	1 329	7.98	72	3 83	2.720	6.694	1.408	G. S. Y. T.	Sour	" "
January 2	411.07	3/16	25.76	44.17	9.95	1.071	9.29	80	3.63	2.932	6.717	1.238	G. Y.....	.....	" "
January 20	388.37	3/16	29.87	42.85	8.85	1.162	7.61	80	3.66	2.340	6.000	1.564	G. Y.....	Rather sour	" "
February 24	433.75	4/16	28.38	47.74	9.9	0.8195	12.08	64	3.72	2.510	6.363	1.482	G. Y.....	.....	
Averages for the season	386.86	7/32	27.05	44.23	10.26	1.226	8.36	73	3.71	3.010	6.879	1.235			

TABLE 37.

Individual Tree Record—Continued.

SEASON 1918–1919.

TREE No. 15—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of
October 28	541.71	3/16	25.26	39.61	10.21	1.403	6.93	64	3 72	.....	.....	.....	G. Y. T.	Rather bitterish and acid	Well filled
November 12	513.12	4/16	25.98	42.37	9.7	1.289	7.52	54	3.92	4.256	8.176	0.921	Y.	Tart.....	" "
November 26	561.31	7/32	26 47	43.62	9.3	1.187	7.83	54	.....	2.749	.....	.....	S. Y....	Sour.....	.....
December	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
January 2	487.62	7/32	25.76	43.81	9.2	1.096	8.39	60	3.36	2.55	6 045	1,317	Y.	.....	Filled
January 20	521.64	9/32	30.24	40.00	9.10	1.007	9.03	57	3.60	2.03	5.737	1.773	Y.S.G.T.	Tart.....	"
Averages for the season	525.08	7/32	26.74	41.88	9.50	1.210	7.85	58	3.65	2.896	6.699	1.260			

TABLE 38.

TREE No. 16—DUNCAN.

Date picked	Average weight in grams	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	419.89	6/16	26.54	29.63	10 94	1.536	7.12	77	.....	.....	.....	.....	G. S. Y. T.	Tart	Filled
November 12	416.71	9/32	29.93	39.46	10 7	1.360	7.86	65	3.62	3.860	7.684	.....	Y. G. T....	"	"
November 26	393.66	3/16	24.30	42.35	10.2	1.455	7.00	80	.....	.....	.....	.....	G. S. Y. T.	Sour	"
December 2	402.57	9/32	32.73	40.44	10 2	1.459	7.00	72	2.07	2.656	4.887	0.779	G.	"	"
January 2	394.04	7/32	26.31	43.42	10.0	1.307	7.65	78	3 83	2.620	6.589	1.461	S. Y.....	"	"
January 20	498.96	7/32	30.58	37.64	9.8	1.284	7.63	69	3.88	2.340	6.344	1.615	S. Y.....	"	"
February 24	405.40	3/16	26.11	47.13	10.7	1.182	9.05	72	4.75	2.431	6.310	1.953	... .	Tart	"
Averages for the season	418.75	8/32	28.07	40.01	10.36	1.369	7.56	73	3.631	2.782	6.77	1.304			

Averages for the season	418.75	8/32	28.07	40.01	10.36	1.369	7.56	73	3.631	2.782	6.77	1.304			

TABLE 39.

Individual Tree Record—Continued.

SEASON 1918–1919.

TREE No. 17—DUNCAN.[1]

Date picked	Average weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	Fruit too green to be picked at this date; ripe fruit had already been picked.														
November 12	275.00	4/16	36.00	28.57	10.30	1.738	5.92	80	3.62	3.421	7.222	1.058	G. Y.	Sour	Hard dry
November 26	331.10	7/32	28.22	36.28	10.50	1.863	6.23	80					G. S. Y. T.	"	Partially filled
December 12	435.73	5/16	21.60	33.79	10.55	1.733	6.08	?	3.19	3.050	6.402	1.045	G.	"	Filled
January 2	396.00	7/32	26.48	38.46	10.55	1.559	6.76	78	3.58	3.760	7.539	0.952	G. Y.	"	"
January 20	402.57	4/16	28.20	32.05	10.45	1.732	6.03	70	3.73	2.734	6.609	1.364		"	"
February 24	453.60	4/16	35.55	26.66	11.70	1.474	7.937	62	4.79	2.745	7.68	1.935	G. Y.	"	"
Averages for the season	382.66	1/4	29.34	32.63	10.67	1.683	6.339	74	3.782	3.142	7.088	1.206			

TABLE 40.

TREE No. 18—DUNCAN.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Average size	Invert sugar	Cane sugar	Total sugar	Ratio of invert sugar to sucrose	Color	Taste	Consistency of cells
October 28	438.04	29.82	41.89	8.44	1.173	7.195	77					G. S. Y. T.	A little sour	Well filled
November 12	551.20	28.46	41.34	8.55	1.111	7.690	50	2.95	4.103	7.270	0.718	S. Y.	Tart	" "
November 26	452.17	25.85	44.55	8.30	1.117	7.430	54	6.27	2.212		2.848	Y. G.		" "
December 12	501.77	26.73	45.35	8.50			64	2.99	2.407	5.529	1.242	G. Y.	A little sour	" "
January 2		25 00	40.56	8.35	0.9712	8.590	57	2.36	2.725	5.229	0.866	G. Y.	Tart	" "
January 20	338.66	28.43	42.15	8.25	0.9619	8.576	56	3.18	2.421	5.629	1.313	G. Y.	"	" "
February 24	484.78	26.08		8.50	0.911	9.330	65	3.80	1.720	5.610	2.209	G. Y.	"	" "
Averages for the season	494.43	27.14	42.64	8.41	1.041	8.07	60	3.59	2.598	6.325	1.381			

[1] Evidently this tree was picked periodically by the plantation owners, so that the fruit left was always unripe. This tree has not been used in the computation of averages.

The average seasonal changes of the fruit during this season was calculated by averaging all the samples picked on the same date and constructing the table that follows. This table, then, shows the mean composition of the fruit on the dates specified.

TABLE 41.

Showing Biweekly Analyses of Fruits.

Sampled from six different groves, and analyzed immediately after picking. (One of the trees included in these averages was Marsh's Seedless.)

SEASON 1918–1919—DUNCAN.

Date picked	Average size	Per cent skin	Per cent juice	Per cent solids in juice	Per cent citric acid	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to sucrose
October 28, 1918.....	490.09	25.91	38.46	9.87	1.318	7.509	3.312	.....	.....	.....
November 12, 1918..	508.31	26.68	41.72	9.44	1.202	7.893	4.040	8.456	4.23	0.955
November 26, 1918..	474.31	24.91	42.93	9.25	1.200	8.820	1.960	5.491	2.66	1.787
December 12, 1918...	476.00	28.19	44.38	9.34	1.218	7.925	3.085	5.853	2.63	1.171
January 2, 1919	468.9	24.83	42.00	9.16	1.060	8.808	3.240	5.980	2.56	1.266
January 20, 1919	502.17	28.40	40.90	9.89	1.187	8.366	3.520	5.828	2.26	1.557
February 24, 1919....	482.57	26.38	45.40	9.76	0.961	9.948	9.920	5.996	2.15	1.828
Averages for the season	486.05	26.47	45.25	9.387	1.164	8.06	3.298	6.078	2.64	1.544

1918–1919.

DISCUSSION OF RESULTS.

As in the previous seasons the results as presented in this set of tables will now be discussed by topics, and the coincidences, as well as the disparities existing between this season's results and those of previous seasons duly pointed out.

DUNCANS.

1918–1919.

Weight and size.—Both these factors show considerable fluctuation, and no definite tendency to either increase or decrease regularly throughout the season. The correspondence of larger weight to smaller juice content in fruits of the same size is again noticeable here.

In tree No. 12 the samples picked on October 28th and November 26th both of size No. 54, show, the former 30.82 per cent juice and a weight of 575 grams per fruit and the latter 44.1 per cent juice and only 541 grams per fruit.

In tree No. 13 the samples picked on November 12th and November 29th, both of size No. 54, show 40 per cent and 43 per cent juice respectively, and their corresponding weights per fruit are 615 grams and 542 grams. In the same tree in the samples picked on October 28th, December 12th and January 20th, all of size No. 64, the highest weight per fruit is shown by the first, 564 grams per fruit, and this is the sample with the lowest juice content of the three.

In tree No. 14, however, with the fruit No. 80 picked on November 26th, January 2nd and January 20th the rule does not hold. This is the first exception of significance encountered.

In tree No. 16 the samples for December 2nd and February 24th, both No. 72, have weights of 402 and 405 grams respectively, with juice contents of 40 per cent and 47 per cent. In tree No. 17 the first two samples, both No. 80, contain the first 28 per cent juice and 275 grams per fruit, and the second 36 per cent juice and 333 grams per fruit. These constitute other exceptions.

It is noticeable that in the last three instance in which the regularity which had been observed so far does not seem to hold the fruits are all very small fruit, Nos. 72 and 80.

Per cent juice.—With the exception of tree No. 14, in all other instances the per cent juice increased as the season advanced. The increase is also shown by the table of averages No. 41. In this table the lowest average was for the samples picked on October 28th, which was 38.46 per cent, while the highest was shown by the samples picked on February 24th, which was 45.40 per cent. The average of all trees for the season was 42.25 per cent, considerably higher than last season's which was 38.97 per cent, but still lower than that for the season 1916–1917, which was 43.57 per cent.

Per cent skin.—There is considerable fluctuation in the per cent skin, both as regards individual trees and in the table of averages. This is in accord with the observations made during the season 1916–1917.

Thickness of skin.—This may be considered constant, with fluctuations. Observations coincide with those for the two previous seasons. Average for the season for each tree usually in the neighborhood of 1/4".

Per cent solids in juice.—In tree No. 12 there are alternate decreases and increases among the succeeding figures, and all but two figures, as well as the average, are lower than the first.

In tree No. 13 there are three increases and three decreases, com-

paring each figure with the one immediately preceeding and immediately following. The average is also lower than the first figure.

Tree No. 14 shows four decreases and one increase. Average lower than first figure.

Tree No. 15 shows a continued decrease, except for the last figure.

Tree No. 16 shows up the same as tree No. 15.

In tree No. 18 alternate increases and decreases within narrow limits are observed. The average is practically equal to the first figure.

The table of averages for all trees for the whole season No. 41, shows the fluctuations noticed among individual trees, with a marked tendency toward the decrease.

The above observations show a tendency of the solids in juice to decrease during this season.

This is not in accord with observations for the two previous seasons, when the solids remained practically constant but with slight tendency to increase. This may be explained on the ground that this fruit was ripe from the start, and the differences noticed are due to sampling.

The average for all the trees for the whole season was 9.387 the lowest average for any date being 9.16 on January 2nd, and the highest 9.87, on October 28th. This is higher than the average for any of the two previous seasons.

Per cent acid.—A mere glance at the figures for acid shows that this factor gets consistently lower as the season advances. The increases are very exceptional, five cases only being observed during the whole season among all the trees. All averages for individual trees are considerably lower than most of the percentages obtained in the succeeding dates they represent. The table of averages for all the trees throughout the season shows an almost continued decrease. This supports the view previously expressed at the beginning of this work.

The highest percentage obtained during this season (see table 41) was 1.318 on October 28th, the lowest was 0.961 on February 24th, and the total average was 1.164. This total average is lower than the averages obtained on any of the dates except two.

These observations coincide with those for the previous two seasons. The highest averages almost coincide in all three seasons, being 1.36 in 1916–17, 1.347 in 1917–18, and 1.318 for 1918–19. This also shows a continued decrease from season to season. The lowest

averages do not agree so closely, being, 1.11 for 1916–17, 1.155 for 1917–18 and 0.961 for 1918–19.

The mean were 1.205 for 1916–17, 1.255 for 1917–18 and 1.164 for 1918–19. The figures for this season, then, are the lowest. However, in general the agreement is remarkable.

Ratio of solids to acids.—In spite of the fact that the solids showed a slight tendency to decrease during this season, the ratio of solids to acids has increased. This proves that the solids increased to a certain extent, but failed to increase proportionately so that their percentages fell off a little. However, the proportion of the acids was so much lower, that the ratio of the former to the latter appeared greater on succeeding dates.

Per cent sugars.—An examination of the tables for the individual tree records does not reveal any marked regularity in the change of the sugar content of the fruit. They rather show a marked tendency on the part of sugars to be constant, as with the exception of a few cases the successive percentages do not differ much from each other. This is again another sign that the fruit had quite reached maturity when the first samples were taken. Furthermore, the averages for the individual trees (see table 42) vary between rather narrow limits. The total sugars ranged from 5.854 for tree 12 to 6.879 in tree No. 14. Cane sugar varied between 2.38 in tree No. 12 and 3.01 in tree No. 14, and invert sugars between 3.20 in trees No. 14 and No. 13 and 3.845 in tree No. 16.

Table 41 showing the averages of all trees for the different dates, however, show something different. The total sugars may be taken as constant, but there is a clear, steady decrease in cane sugar, and a very perceptible tendency to increase on the part of invert sugar.

The averages for all the season were 6.078 per cent total sugars, 2.64 per cent cane sugar, and 3.298 per cent invert sugar.

RELATION OF PHYSICAL CHARACTERISTICS TO RATIO OF SOLIDS TO ACID.

Turning now to the observations made on color, taste, and consistency of cells. In tree No. 12 the ratios were all above 8, the samples were all more or less green, with the exception of the one picked on December 12th, the taste in all cases was designated as "tart," and the cells were all well filled. This fruit showed all the characteristics of a perfectly mature fruit except for the color. Notice that a ratio of more than 8 was reached as early as October 28th and that the fruit was yet far from dropping.

Tree No. 13.—All samples showed green more or less. The greenest looking fruit was that picked on October 28th with a ratio of nearly but not quite 8. The taste of this sample was rather bitter, showing that it could yet improve. However, its cells were filled and juicy. All other samples picked from this tree were tart in taste, and had well-filled juicy cells. Again we see that although the color was fairly green, the ratio was way over 7, very nearly 8, from the beginning, being over 8 in all instances except the first.

Tree No. 14.—In this case we have two samples, picked one on December 12th and the other on January 20th, whose juices were sour. The first was rather green, having only a slight yellow tinge, and the second was slightly less than 50 per cent green. Although they had their cells well filled, showing that they were fully developed, yet they could not be considered as good to eat: however, their ratios were over 7 and very near 8. This shows that the ratio of 7 is reached before the fruit has reached complete maturity for this variety.

Tree No. 15.—Notice the first and the third samples picked on October 28th and November 26th respectively. The first sample had not quite reached 7, although it might be passed as having a ratio of 7. Its color was mostly green, having only a yellow tinge, and its taste was bitter and sour. This fruit evidently had not reached maturity and was not fit to eat. This shows that the Duncan fruit does not mature here before reaching a ratio of 7. The fact that its cells were well filled only shows that it was approaching maturity, and that the limit of maturity lies somewhere between the ratios of 7 and 8, and that therefore 7 is the minimum limit allowable. In the second instance the fruit was yet rather sour, although the ratio was nearer 8 than 7.

Tree No. 16.—The samples picked on November 26th, December 2nd, January 2nd and January 20 th vary in ratio between 7 and 7.65. In them all, the green color predominates, the first two being almost entirely green. It may be noticed that the first two have a ratio of just 7. Their cells were filled, but not to perfection, thus lacking another sign of maturity. All of these samples were sour. So we have that the color, the condition of the cells, and the taste of the juice, all bespeak an immature fruit, yet their ratio was not below 7. This proves that this fruit does not mature before a ratio of 7 is reached.

Tree No. 17.—No sample from this tree except the last shows a ratio of 7. This is due to the fact that the fruits were picked as

they matured by the person in charge of the plantation, so that when the samples were picked for analysis, only immature fruit was found on the tree. For this reason this tree has not been used in the computation of averages. All of the samples except the last were sour. None of the samples had their cells perfectly well filled, and the first, with the lowest ratio, had its cells especially hard and dry.

Evidently all samples except the last were very immature. This is another instance where fruit with ratios below 7 have shown themselves to be unfit for consumption.

Tree No. 18.—The first and fourth samples, in which the green color predominated were a little sour. However, their cells were "well filled" and "filled" respectively, so that they might be considered as just on the border line of maturity. The ratio of the first was 7.19. The ratio of the second could not be calculated as the acid determination was spoiled; however, it may safely be assumed to have been over 7. This is further evidence to show that a fruit does not show a ratio of 7 may be regarded as immature. The rest show signs of maturity in their taste and the consistency of their cells, although the green color predominates. Their ratios are well over 7.

To summarize.—There has not been a single instance where fruits with a ratio of less than 7 have shown signs of maturity, regarding as such the color, taste, and consistency of the cells. That is, every fruit with a ratio of less than 7 has been found to be immature.

Every fruit showing signs of maturity have been found to have a ratio of more than 7 and very nearly 8.

The divisory line between mature and immature Duncan fruit, then, seems to lie between 7 and 8, and perhaps nearer 8 than 7.

Turning now to the table of averages of all the trees for different dates we find than the lowest average ratio of solids to acid, 7.509, occurred on October 28th (the first picking of the season), the highest, 9.948, on February 24th (the last picking), and that the average for all the trees for the whole season was 8.06. This is higher than in any of the previous seasons.

The changes that so far have been observed to characterize the process of maturation have been hardly noticeable, if at all, during this season. This may be taken as an indication, that in a general way the maturation of the fruit had come to completion when the

first samples were picked. In a large measure this was so, as a review of the tables and the discussion shows.

This season the fruit contained more juice, and more solids in the juice, and had a higher average ratio than in previous years. This again might show a more perfect state of maturity.

COMPARISON OF TREES.

1918–1919.

The mean composition of the fruit for the season for each separate tree, is given below in—

TABLE 42.

Showing Mean Composition of Grapefruit for the Season for Each Individual Tree.

DUNCAN—SEASON 1918–1919.

Tree No.	Average weight in grams per fruit	Average size	Thickness of skin	Per cent skin	Weight of fruit per box in grams	Per cent juice	Solids in juice	Acid (citric)	Ratio of solids to acid	Invert sugar	Total sugar	Cane sugar	Ratio of invert sugar to sucrose
12	584.7	49	1/4	24.41	28,653	40.97	8.80	0.997	8.82	3.3478	5.854	2.382	1.405
13	523.5	69	1/4	25.33	36,121	42.25	8.61	1.031	8.35	3.2000	5.9270	2.590	1.235
14	386.8	73	7/32	27.05	28,240	44.23	10.26	1.226	8.36	3.7100	6.879	3.010	1.235
15	525.0	58	7/32	26.74	30,454	41.88	9.50	1.210	7.85	3.6500	6.699	2.896	1.260
16	418.7	73	1/4	28.07	30,868	40.01	10.36	1.369	7.56	3.6300	6.770	2.782	1.304
17 (1)	382.6	74	1/4	29.34	28,316	32.63	10.67	1.683	6.34	3.7820	7.088	3.142	1.206
18	494.4	60	.....	27.14	29,655	42.64	8.41	1.041	8.07	3.5900	6.325	2.598	1.381

[1] The samples picked from this tree were all of immature fruit, as the plantation people picked the fruit as it matured, so that only unripe fruit was left on the tree. For this reason these figures were not included in the averages.

Disregarding tree No. 17, we find that all trees had an average ratio of solids to acid higher than 7. Two trees, Nos. 15 and 16, had ratios lower than 8 but much higher than 7. The other trees had all ratios higher than 8, and quite near each other, the largest difference not reaching 0.8.

The thickness of skin, per cent skin, and weight of fruit per box are fairly uniform for most of the trees. The same is true in a large measure as regards the sugars. The greater differences come in the percentages of acid and solids. The highest acid content and percentage of solids correspond to the tree with the lowest ratios of solids to acid (tree No. 17 excepted), tree No. 16. The lowest acid is shown by the tree with the highest ratio, and with the exception of tree No. 14 the percentages of acid get lower as the ratios are higher. Excepting this same tree No. 14, the percentages of juice for the different trees show a fair degree of agreement.

Tree No. 17 is conspicuous among all the others. Its fruit showed less weight per fruit, and smaller size than any other. It also had a higher percentage of skin, acid, and soluble solids, and a lower content of juice and ratio of solids to acid than any other. The color of the fruit was for the most part green throughout the season, the taste of all the samples was sour, and the cells were never "well filled." Evidently every sample picked was immature. These results suggested a number of considerations, chief among which was the one that most of soluble solids, acids included, are manufactured rather early in the season. It is evident that the juice continues to increase and the skin to decrease until maturity is reached. To get an idea as to the correctness of these views the following tests were made:

Three samples of green fruit were picked from the trees of the Station grove. The samples were marked 1, 2, and 3.

Sample No. 1 was composed of 4 fruits with a very pale yellowish color, very scabby and very hard. The cells or juice sacs, however, were fairly well filled, so that the juice could be extracted by hand pressure. This juice was very sour.

Sample No. 2 was wholly green in color, very hard, containing so little juice that only a very few cubic centimeters could be squeezed out when using the strongest hand pressure. This juice tasted sour and bitter.

Sample No. 3.—This fruit was of an intense green color, very hard, not yielding any juice when squeezed with the hand. When extracted with water the extract had a strongly bitter taste.

Sample No. 1 was squeezed and the juice obtained used for the tests to be described, but in samples numbers 2 and 3 which hardly had any juice, the peeled fruits were extracted with an equal weight of water, and the dilution of the extract calculated from the loss in weight of the pulp, the weight of the extract, and the amount of water used. All results were then figured back to undiluted juice. All measurements and determinations already described were performed on these samples, with the following results:

	Sample No. 1	Sample No. 2	Sample No. 3
Size of fruit	3-5/16 inches diameter	3.1 inche diameter	3-5/16 inches diameter
Thickness of skin	3/8 inche diameter	1/2 inche diameter	9/16 inches diameter
Per cent skin	52.63	48.33	58.82
Per cent juice	21.53	11.87	5.91
Solids in juice	10.68	18.06	27.63
Per cent acid	1.415	2.234	2.928
Ratio of solids to acid	7.5	7.30	9.4

The sugars present in these samples may be considered as negligible. A qualitative test of the juice revealed the presence of sucrose, but when polarized after clarification with Horne's dry lead, samples 1 and 2 read less than 0.1 while sample No. 3 did not seem to affect the polarized light at all. As the polarimeter used did not read below 0.1 no estimate of the negligible reading given by the first two samples is presented. These fruits must have been from 3 to 4 months old.

After deleading the clarified juice with sodium oxalate, inverting with hydrochloric acid and neutralizing, the invert reading on the polariscope was negligible for samples Nos. 2 and 3, and gave about 0.4 for sample No. 1. This shows an almost complete absence of sugars in samples 2 and 3, and very negligible amount in sample No. 1. However, the unclarified juices of all three samples gave copious precipitates when treated with an alkaline copper sulphate solution. Calculating the reduced copper to invert sugar, we obtained 24.3 per cent for sample No. 1, 17.44 per cent for sample No. 2, and 19.01 per cent for sample No. 3. Clearly, the fruit was just beginning the elaboration of sugars at this stage of this development. It is presumed that this elaboration continue until full maturity is reached, when inversion of the sucrose accumulated begins.

The conclusion is warranted that the green fruit contains a goodly amount of reducing bodies, probably glucosides, and tannin bodies,

which may be responsible for the bad effects attributed to immature fruit.

The figures further show rather conclusively the following points:

1. Most of the juice is formed toward the latter part of the period of development.

2. The thickness of the skin diminishes gradually after the first stage of development of the fruit, as does also the percentage of skin.

3. Most of the solids, sugars excepted, are formed very early in the development of the fruit.

From the above observations taken together with the other data at hand the conclusion may be reached that at maturity the formation of solids stops, the juice also stops increasing, the percentage of skin and the percentage of acid diminishes, the amount of total sugars remains constant thereafter, and inversion of sucrose and decomposition of invert sugar set in. These changes, then, ought to mark the point of maturity of the fruit. Of course, it would require further work, more detailed in character, to ascertain the true nature of these changes.

All the previous data sufficiently prove that grapefruit here is capable of reaching a ratio of solids to acid in solution in its juice equal to 7, and that their maturity occurs when this ratio or some higher ratio is obtained. There is a possibility, however, of the Marsh's Seedless coming to maturity with a ratio lying between 6.5 and 7.0.

COMPARISON OF VARIETIES.

For the purpose of illustrating the comparisons about to be made of the three varieties of grapefruit tested, three tables are given showing the mean composition of each variety on approximately coincident days of the succeeding years.

These tables were constructed in the following manner: For each variety the analyses of all samples picked on the same or approximately the same day of the month in each month from September to February of the different years involved, were averaged to represent the mean composition of the fruit on the specified day and month. With these data a table was constructed for each variety showing the mean variation of the composition of the fruit during the period of observation. By averaging all the figures thus obtained for the succeeding days, the mean composition of the fruit for the total time of observation was obtained.

TABLE 43.

Showing Biweekly Analyses of Grapefruit from Two Different Groves.

TRIUMPH—Season 1916–1917.

Date picked	Average weight	Average size	Average weight per box in grams	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	Invert sugar	Cane sugar	Total sugar	Ratio Invert to cane sugar
September 22	332.			31.35	24.45	9.80	1.08	9.0	2.93	4.04	7.180	0.725
October 5–6	429.	80	84,320	32.41	28.87	9.60	1.04	9.2	2.41	3.92	6.568	0.520
October 23	340.	64	21,760	30.88	31.31	9.45	0.99	9.5	3.18	3.19	6.539	1.000
November 3	394.5	90	35,505	26.47	33.92	10.10	0.92	10.9	2.81	3.54	6.537	0.790
November 21	324.5	82	26,609	23.64	35.88	10.10	0.91	11.1	3.58	2.39	6.090	1.500
December 8	400.	92	36,807	28.29	35.57	9.80	0.85	11.15	2.77	3.95	6.929	0.700
December 29	388.5	82	31,850	25.39	35.84	10.30	0.73	14.1	3.42	2.81	6.379	1.210
January 19	405.0	66	26,730	32.57	35.12	10.20	0.76	13.4	3.50	2.85	6.500	1.23
February 19	491.	54	26,614	30.93	29.66	9.50	0.70	13.57	3.50	2.74	6.385	1.27
Averages for the season	387.16	76	30.024	29.10	32.41	9.872	0.887	11.12	3.125	3.27	6.568	0.9556
Rate of change				-0.0577	0.579	-0.0333	-0.0422		0.0633	0.0333	0.0833	

TABLE 44.

Showing Average Biweekly Analyses of Fruit for the Seasons 1916–1918.

MARSH'S SEEDLESS.

Date picked	Average weight in grams	Average size	Average weight per box in grams	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acid	(1) Invert sugar	(1) Cane sugar	(1) Total sugar as invert	Ratio invert to cane sugar
September 21-23	555.5	41	22,775	30.195	41.845	8.465	1.236	6.85	3.50	2.01	5 63	1.741
October 3-6	461.0	55	25,359	28 520	42.210	7.945	1.245	6.38	2.77	2.08	4.97	1.331
October 20 25	496.2	60	29,771	28.435	40.190	8.355	1.238	6.75	2.52	1.48	4.32	1.702
November 3-17	469.9	58	27,254	28.045	39.210	8.315	1.175	7.07	3.01	1.60	4.73	1.88
November 21	476.0	56	26,696	27.440	49.350	7.831	1.067	7.34	3.20	1.57	4.39	2.038
December 8-10	559.75	53	29,667	31.475	42.675	8 330	1.109	7.51	2.59	2.08	4.89	1.293
December 20-29	539.0	55	29,645	33.810	45 510	7.900	1.062	7.44	2.96	1.95	5.08	1.518
January 10-20	550.5	54	29,727	26.575	42.810	8.805	1.195	7.37	3,54	1.60	5.12	2.212
February 9	493 0	64	31,552	33.100	46.970	7.600	1.060	7.17	3.67	1.35	5.14	2.718
February 24	534.0	56	29,904	29.140	49.900	7.200	0.950	7.58	.....	.....	.....	.....
Averages for the season	510.56	55	28,234	30.67	44.06	8.07	1.134	7.12	3.079	1.658	4.825	1.857
Rate of change	.....	.....	.....	-0.117	1.271	-0.141	.....	.....	-0.0633	-0.128	-0.191	.....

TABLE 45.

Showing Summary of Biweekly Analyses of Duncan Fruit for the Seasons (1916–17, 1917–18, 1918–19).

DUNCAN VARIETY.

Date picked	Average weight	Per cent skin	Per cent juice	Per cent solids in juice	Per cent citric acid	Ratio of solids to acids	Per cent invert sugar	Per cent total sugar	Per cent cane sugar as invert	Ratio of invert sugar to sucrose	Average size	Weight per box in grams
September 21–25	597.85	26.62	39.98	8.68	1.359	6.39	3.010	5.358	2.23	1.35	51	30,490
October 4–6	573.46	26.89	42.18	8.81	1.334	6.61	2.880	5.510	2.25	1.28	57	32,687
October 25–28	555.84	25.77	41.00	9.09	1.267	7.17	3.147	5.474	2.21	1.42	58	32,238
November 3–17	552 53	25.77	40.10	9.14	1.193	7.66	3.340	6.390	2.90	1.15	54	29,836
November 21–26	528.15	25.59	43.92	8.92	1.210	7.37	2.800	5 220	2.30	1.22	63	33,273
December 8–21	552.42	27.67	42.79	9.21	1.173	7.85	3.118	5,476	2.24	1.39	53	29,278
December 29 to January 2	566.95	26.20	43.94	8.99	1.093	8 22	3 310	5,658	2.23	1.48	59	33,400
January 17–22	559.05	27.68	42.33	8.97	1.174	7.64	3.280	5,407	2.02	1.02	57	31,865
February 15–24	482.57	26.88	45.40	9.76	1.961	9.95	3.930	6.194	2.15	1.83	52	25,093
Averages for the season	552.09	26.51	42.40	9.06	1.196	7.57	3.201	5.603	2.281	1.40	56	30,912
Rates of changes	.....	-0.0377	0.602	0.010	-0.0464	0.395	0.102	-0.0929	-0.01	.....	.....	.....

RATE AT WHICH FRUIT REACHED THE LEGAL RATIO OF 7 (RATIO OF SOLIDS TO ACID).

All of the triumph fruits sampled always showed a ratio considerably higher than 7, even though picked quite early in the season. The lowest average ratio noticed was 9, on September 22nd, when the first sample was picked. At the early date already 100 per cent of the fruit had a ratio of solids to acid higher than the legal ratio of 7. The highest ratio was shown by the sample picked on December 29th, which was 14.1, thus attaining a maximum increase of 5.1 in its ratio in the space of 98 days. These data may be best shown in the following:

TABLE 46.

Showing Rate at Which Fruit Approached the Legal Ratio of 7.

TRIUMPH VARIETY—SEASON 1916-1917.

Months and days	Average ratio of all samples picked within days noted on previous column	Per cent of samples found to have a ratio of 7 or more
eptember 22	9.00	100
October 5-6	9.20	100
October 23	9.50	100
November 3	10.90	100
November 21	11.10	100
December 8-9	11.15	100
December 29	14.10	100
January 18	13.40	100
February 8	13.57	100

As seen from the table the development of the ratio may be divided into three periods, for this fruit. From September 22nd to October 23rd, the ratio varied very little, the maximum range of variation being only 0.5, and the average ratio for the two months being 9.23. On November 3rd the ratio increased to 10.9 and stayed there practically another period of two months during which the average ratio was of 11.05. Then on December 29th, the rato jumped up to 14.10, the highest ratio attained during the season, after which no more increases were noticed, but rather slight decreases, ending two months later with a ratio of 13.57, an average of 13.69 for the period. This fruit reaches the highest ratios of all, reaches the legal ratio of 7 the earliest of all, and its ratio increases at the fastest rate.

The opposite extreme is supplied by the Marsh's Seedless variety. Notice the table given below:

TABLE 47.

Showing Rate at Which the Fruit Approached the Legal Ratio of 7.

MARSH'S SEEDLESS VARIETY.

Months and days	Average ratios of all samples picked within days noted in previous columns		Per cent of samples found to have a ratio of 7 or more	
	Season 1916-1917	Season 1917-1918	Season 1916-1917	Season 1917-1918
October 21-25.....	6.74	6.82	33.3%	50%
November 3-21.....	7.09	7.31	80.0%	66.6%
December 8-29.....	7.45	7.55	100.0%	100.0%
January 18-24.....	7.34	7.39	100.0%	100.0%
February 9-24.....	7.34	.....	100.0%	.....
Maximum range...	0.71	0.73	....	.....

The maximum range of variation in ratio during the season was 0.71 for the season 1916–17 and 0.73 during the season 1917–18. The legal ratio of 7 was not attained until some time between November 3rd and 21st, and then only 80 per cent of the fruit in 1916 and 66.6 per cent of the fruit in 1917 came up to the standard. Not until December 8th to 29th did 100 per cent of the fruit come up to the legal ratio. At this time the maximum ratio for the season was reached, which was 7.45 in 1916 and 7.55 in 1917. It should be remarked, however, that in the season 1917–1918, 50 per cent of the fruit had attained a ratio of 7 on October 21st to 25th when in the 1916–17 season only 33.3 per cent of the fruit had attained this ratio within the same dates, thus showing that the fruit matured earlier in 1917–18 than in 1916–17.

Mean between these two extremes we find the Duncan Variety.

TABLE 48.

Showing Rate at Which the Fruit Approached the Legal Ratio of 7.

DUNCAN VARIETY—SEASONS 1916–1917, 1917–1918, 1918–1919.

Months and days	Average ratio of all samples picked within days noted in previous column			Percent of samples found to have a ratio of 7 or more		
	Season 1916-1917	Season 1917-1918	Season 1918-1919	Season 1916-1917	Season 1917-1918	Season 1918-1919
September 22-25....	6.2	7.28	.....	0%	50.00%	.....
October 4-28 ...	5.7	7.24	7.51	16.6%	57.00%	100
November 3-21....	7.25	7.98	8.30	75.0%	71.40%	100
December 8-29....	7.75	8.00	7.92	100.0%	100.00%	100%
January 2-22....	7.80	7.74	8.60	100.0%	100.00%	100%
February 24.....	.....	.....	9.95	.....	.....	1.100%
Maximum range..	1.60	0.72	2.44	.....	.....	.....

It is true that during 1916 to 1917 the legal ratio of 7 was not attained until November 3rd to 21st, as in the case of the Marsh Seedless, but during 1917 to 1918, this ratio was reached as early as September 22nd, when already 50 per cent of the fruit had attained it. Then again the maximum average ratios were higher for this fruit, and the ratio kept on increasing for a longer period of time. The ranges are also wider, during 1916–17 and 1918–19. However, during the two consecutive seasons 1916–1918 both varieties showed 100 per cent legal maturity within the same period of time. The season 1918–19 is exceptional, as it was the driest of all, and as no Marsh Seedless fruit was tested during this season no comparison can be made.

The relation of these varieties to each other in this respect may best be seen from the following table, which shows averages for each variety for definited dates through the consecutive seasons during which they were tested:

TABLE 49.

Showing Rate at Which Fruit Approached the Legal Ratio of 7.

AVERAGE FOR ALL THE SEASONS, 1916–1919.

Dates	Average rate			Per cent averages of fruit with ratio of 7 or more on previously noted dates		
	Duncan	Marsh's	Triumph	Duncan	Marsh's	Triumph
September 21-25....	6.39	6.86	9.0	[1]25.00%	.....	100
October 4- 6....	6.61	6.38	9.2	.....	.....	100
October 20-28....	7.17	6.95	9.5	57.8%	41.6%	100
November 3-26	7.01	7.20	11.0	82.0%	75.3%	100
December 8-29....	7.85	7.48	12.5	100.0%	100.0%	100
January 2-22....	8.13	7.37	13.4	100.0%	100.0%	100
February 9-24 ...	9.95	7.38	13.5	100.0%	100.0%	100

[1] For two seasons only, in 1918 the first sample of fruit was picked in October.

Tests with the Duncan variety have been carried for three seasons; with the Marsh's Seedless through two seasons, 1916–1918, and the Triumph for only one season, 1916–1918.

The maximum ranges as given by this table are 4.5 for the "Triumph," 3.56 for the "Duncan," and 0.62 for the "Marsh." The maximum average ratios attained within the periods specified were 13.5 for the "Triumph," 9.95 for the "Duncan" and 7.48 for the "Marsh." The "Triumph," as already stated, had a ratio higher than 7 from the beginning. The Duncan showed the legal ratio for the first time during the last week of October and the Marsh during the middle two weeks of November. Both in the case of the Duncan and the Marsh 100 per cent maturity was ob-

tained some time during the second and third weeks of December. Notice that the ratios of the Duncan and the Triumph keep on increasing through the season.

The rates of increase of the ratios as well as the maximum ratios attained, are then in the order "Triumph," "Duncan," "Marsh."

According to these results the date of legal maturity of the "Triumph" comes at a very early date, long before September 22nd, while most of the "Duncan" and the "Marsh" mature some time during the month of November—November 3rd and 26th. By December all varieties show perfect maturity.

Acids and solids.—It has been found that the ratio of solids to acids and its rate of increase is greatest for the "Triumph," least for the "Marsh" and medium between these extremes for the "Duncan." As this rate depends upon the rate of change of the solids and acids we will take this up next. The highest percentage of solids in solution is shown by the "Triumph," the next higher one by the "Duncan," and the lowest by the "Marsh"; not only this, but the lowest acid content is also shown by the "Triumph." However, in the "Marsh Seedless" the percentage of acid is higher than in the "Duncan." It appears then that the higher ratios that obtain in the "Duncan" as compared with the "Marsh" are due to the higher content of soluble solids, coupled with a lower acid content.

Now as to the rates of increase. The rate of increase in this, as in all other instances was calculated by finding the differences between the succeeding figures starting with the first, and marking the differences, positive or negative, according as the figure that followed was larger or smaller than the one immediately preceding it with which it was compared. All the positive and negative differences were added together and the difference between the sums, found. This difference indicated, then, the direction of the variation, whether toward an increase or a decrease. As the periods of time between the succesive dates were practically the same, this difference was divided by the number of approximately equal periods covered, and the quotient taken as the mean variation per period. To illustrate, take the column headed "Per cent solids" in table No. 43, page 81. The succesive differences are as follows:

9.6 minus 9.8 = — 0.2	9.8 minus 10.10 = — 0.3
9.45 minus 9.6 = — 0.15	10.3 minus 9.8 = + 0.5
10.10 minus 9.45 = + 0.65	10.2 minus 10.3 = — 0.10
10.10 minus 10.10 = 0	9.5 minus 10.2 = — 0.70

The sum of the positive figures is plus 1.15. The sum of the negative figures is — 1.45. The difference between the sums is — 0.30. As there were 7 approximately equal intervals of time between September 22nd and January 18, but the time elapsed from January 18th to February 19th was about twice as large as the others, we may take the whole time as representing 9 approximately equal periods. Dividing, then, 0.30 by 9 we obtain — 0.0333. That is, the solids in general decreased at the rate of 0.0333 per cent every fifteen days (approximately). The figures so obtained will be taken to represent the rate of change of the different items. In the same manner the rate of change of the percentage of acid was found to be — 0.0422. As seen, the acids decreased at a faster rate than the solids, thus giving rise to an increase in the ratios. Notice, besides, that whereas the decrease in the solids occurs only at intervals, the decrease of the acid is continuous and practically without interruption. This makes the increase in the ratios more marked still.

Taking now the "Marsh's Seedless," it will be noticed that both solids and acids seem to diminish, but in this instance the rate at which the acids decrease, 0.0316, is much lower than the rate of change of the solids (— 0.141). Comparing this variety in this respect with the "Triumph" we find that in the latter the rate of decrease of the solids is only about three-fourths as a large as that of the acid, while in the former the solids diminish at a rate which is over four times as large as that at which the acid decreases. In the "Duncan" the rate at which the acid decreases,—0.0464, is practically the same as in the "Triumph," but the solids show a slight increase (at a rate of plus 0.010) instead of a decrease. In spite of this the rate of increase of the ratio of solids to acid in the "Triumph" is larger. This may be accounted for again by the fact that the decrease in acid in the "Triumph" is practically an uninterrupted process (only one increase of 0.03 having been noticed) while in the "Duncan" two increases, one of 0.01 and another of 0. 06 occur. Besides, the rate of decrease of the acid is slightly larger in the "Duncan." These differences in the rates of change of the soluble solids and acid in the different varieties account for the order in which they come to maturity.

Per cent sugars.—The percentage of total sugars is highest in the "Triumph," less in the "Duncan" and least in the Marsh; 6.568 per cent for the first-mentioned variety, 5.603 per cent for the second, and 4.825 per cent for the last. The proportion of total sugars to

total solids varies also in this order, being 0.655 for the "Triumph," 0.618 for the Duncan, and 0.598 for the Marsh. So, then, the chief differences between the first two varieties that might be made to account for the differences in the taste of their juice is the proportion of solids to acid. The "Marsh" differs from the "Duncan" chiefly in the proportion of total sugars to solids, and from the "Triumph" in both the ratios mentioned. This accounts for the superiority of the "Duncan" over the other two varieties, as regards quality of juice. The staleness of the "Triumph" is due to lack of acid, and the rather insipid taste of the "Marsh" may be attributed to lack of sugar; besides, this last variety also has a little less acid than the "Duncan."

Another interesting point of comparison is the proportion of invert sugar to sucrose. The "Triumph" contains nearly as much invert sugar as sucrose, the ratio of the former to the latter being 0.9556, although in some instances this ratio has been as high as 1.50. Next higher in the ratio of invert sugar to sucrose is the "Duncan" with an average ratio of 1.40, and the highest is the "Marsh" with an average ratio of 1.857. The order in which the varieties stand in the other respects considered has been here reversed, with the "Duncan" always occupying the middle position. This high ratio of invert sugar to sucrose in the "Marsh," however, is not due to an exaggerated percentage of invert sugar, but rather to a low percentage of sucrose, of which it contains the least amount, 1.658 per cent. The highest percentage of cane sugar is contained by the "Triumph" variety, with 3.27 per cent, while the "Duncan" again occupies the middle position with a content of 2.281 per cent. In invert sugar the three varieties were about the same, the order being 3.301 per cent for the "Duncan," 3.125 per cent for the "Triumph," and 3.079 for the "Marsh."

Weight and size.—There were variations in weight between somewhat narrow limits for a given variety but these variations were irregular. The sizes, though varying between wider limits, did not show any regularity, either, in their variations. The "Triumph" showed the smallest average size, number 76; and the least weight per fruit, 387.16 grams. The Duncan and the "Marsh" had about the same size, number 56 for the former and number 55 for the latter, while their weight per fruit did not differ very much, being 552.09 grams for the "Duncan" and 510.56 for the "Marsh." The weights per box, however, were rather uniform for the three varieties, 28.234 kgms. (62.115 lbs.) per box for the "Marsh,"

30.024 kgms. (66.052 lbs.) for the "Triumph," and 30.9721 kgms. (68.1'8 lbs.) for the "Duncan." This would seem to indicate that the differences in weight are affected only very little by the variety, and that they are mostly affected by the size of the fruit. This statement as well as the fact that after the fruit is fully developed its weight is not affected by the time of picking may be fully demonstrated by the following data:

Eighty fruits were picked each month from September to January inclusive from each of the trees marked G, E, H, B, D, F. This fruit, which was used in the experiment to detect the changes brought about by sweating to be described further on, was all measured and weighed, and the weights of all fruits of the same size for each separate month were averaged. The averages obtained for the most common sizes were as follows:

Average Weight in Grams per Fruit.

Size	September	October	November	December	January
36	823	682	833	761	.....
46	573	631	626	658	680
54	573	544	562	539	.....
64	517	501	531	500	586

The average weights of all the samples of fruits of the same average size picked on the different seasons were in turn averaged to find the mean weight of each size for each season, and for all the seasons for which it was tested. The results are given below in tabular form:

TABLE 50.

Showing Weight of Fruits in Grams pre Fruit by Seasons and by numbers.

Size of fruit	1916-1917			1917-1918			1918-1919			Averages for all three seasons		
	Maximum	Minimum	Averages	Maximum	Minimum	Averages	Maximum	Minimum	Averages	Maximum	Minimum	Averages
No. 36	1066	713	756	713	667	690	.....	.....	.....	889.5	701.5	723.0
No. 46	766	566	650	691.6	576.5	347.9	636	556	596	697.8	566.1	631.3
No. 54	658	409	554	585.8	463 0	548.3	615	452	545	619.6	441.3	549.1
No. 64	658	317	513	510.0	415.0	469.9	564	417	483	577	377.3	488.6
No. 72	.....	.....	.....	424.4	391.0	408.9	405	405	403	414.6	395.5	405.5

These figures have all been obtained from averages of samples containing from 6 to 12 fruits each.

The number of samples considered for each size in each season are as follows:

Size	1916-17	1917-18	1918-19
36	8	2	.....
46	58	16	3
51	101	12	12
61	68	8	9
72	.....	4	3

The first of these tables shows that the month in which the fruit was picked has not apparently affected the weight of the fruit, while the second table shows the influence of size, which is the most influential factor affecting weight. The scant influence of the variety on the weight per fruit may be seen from previous tables.

Juice and skin.—In all varieties the juice increased perceptibly and the skin decreased very slightly. The rates of changes, however, differed for the different varieties. The "Marsh" showed the fastest rate of increase of juice, as well as the highest juice content of all, 1.274 and 44.06 per cent respectively. Next followed the "Duncan" with a percentage of juice of 42.40 per cent, and a rate of increase of 0.602, and finally the "Triumph," which had only 32.41 per cent juice and a rate of increase practically the same as the "Duncan," 0.579.

As regards percentage of skin the "Marsh" has the highest, 30.67 per cent, as well as the highest rate of decrease, 0.117. Next comes the "Triumph" with a skin content of 29.10 per cent and a rate of decrease of 0.0577, and finally the "Duncan" with only 26.51 per cent of skin and a rate of decrease of 0.0037. This again shows the "Triumph" to be the poorest of the three varieties in quality, as it has much less juice than either the "Duncan" or the "Marsh," and quite as much skin as the "Marsh". The "Duncan" again stands out as the best, as it contains practically as much juice as the "Marsh," and much less skin.

SUMMARY.

We have, than, the folowing prominent points brought out by this comparison:

1. The "Triumph" is the variety attaining the highest ratio of solids to acids, exhibits the fastest rate of increase in this ratio, and reaches the legal ratio of 7 the earliest of all.

2. The "Marsh" matures with the lowest ratio of solids to acids of all, the rate at which this ratio increases is very slow, and it does

not reach the legal ratio of 7 in an appreciable proportion until the latter part of November.

3. The "Duncan" occupies a somewhat middle position between the "Marsh" and the "Triumph" as regards the points of comparison enumerated.

4. The percentages of solids show, in general, a decrease, both in the "Triumph" and in the "Marsh," the rates, however, being faster in the latter. In the "Duncan" this item increases slightly during the process of maturation. The percentage of acids decreases in all three varieties, but at fastest rate in the "Triumph" and lowest in the "Marsh." As to actual percentages of solids in solution the "Triumph" shows the highest, followed by the "Duncan" and lastly the "Marsh." In acid content, however, the order is reversed, the highest being the "Marsh," followed by the "Duncan" and lastly the "Triumph."

5. The total sugars vary in descending order of "Triumph," "Duncan," "Marsh." The relative percentages of sucrose stand again in the descending order already pointed out, while the percentages of invert sugar are very nearly the same in the three varieties. This makes the ratio of invert sugar to sucrose to increase in the above mentioned order of "Triumph," "Duncan," "Marsh."

6. All posible sizes and weights can be found in any variety. The weights per fruit are not as much affected by varieties, as by other factors, especially size. After the fruit has developed to normal size there is no difference introduced in its weight by the time of picking of the fruit.

7. The "Marsh" and the "Duncan" have about the same content of juice, while the "Triumph" has much less than either. The "Marsh" and the "Triumph" rather coincide in their percentages of skin, the "Duncan" having a lesser percentage than either.

CHANGES IN THE PROPORTION OF PLANT-FOOD CONSTITUENTS OF THE FRUIT.

SEASONAL CHANGES.

In the samples of fruit picked during the season 1918–1919 the nutritive ingredients contained by the fruit were determined, as already explained. The tables presenting the results of the analyses are given below. One table has been prepared for each tree, showing the seasonal changes of individual trees in the proportion of these ingredients. By averaging the results for all samples picked

on the same date the mean seasonal variation of the trees tested is given in tabular form. Tree No. 17, whose matured fruit was always picked before samples for analysis were secured, has been excluded from these averages.

INDIVIDUAL TREE RECORDS.

These tables represent the seasonal variations of each individual tree. They were constructed by tabulating the results of the analyses of the successive samples picked from each tree.

In the discussion that follows only the percentages calculated on the whole fruit inserted in the column headed "Original basis" are used for comparison.

TABLE 51.

Nutritive Elements in Grapefruit—Whole Fruit.

TREE No. 12—SEASON 1918–1919.

Dates on which samples were picked	Dry matter	Ratio of solids to acids	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	15.79%	8.260	0.241 %	0.0381 %	0.955	0.1507	.....	.....
November 26.....	14.46	8.965	0.257 %	0.0370	0.800	0.1160	0.672	0.1000
January 2.....	13.94%	10.320	0.384	0 0190 %	1.033	0.1440	0.784	0 1030
January 20.....	15.00%	9.240	0.368 %	0.0550 %	0.924	0.1390	0.7195	0.1080
February 24.....	11.31	10.510	0.558	0.0630	1.190	0.1346	0.358	.....
Averages.....	15.10	9.459	.3616	0.04842	0.9804	0.1368	0.5461	0.1036

This table shows higher phosphoric-acid contents corresponding to higher ratios, as well as a gradual increase in this item in each succeeding sample.

There are practically no variations in nitrogen.

The differences in potash are within the limits of error in sampling and analyzing except for the sample picked on November 26.

TABLE 52.

Nutritive Elements in Grapefruit—Whole Fruit.

TREE No. 13—SEASON 1918–1919.

Date in which samples were picked	Dry matter	Ratio of solids to acids	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	16.57	8.680	0.285	0.0472	0.720	0.119	0.806	.....
November 26.....	12.73	8.309	0.260	0.0330	0.900	0.114	0.515	.....
January 2.....	13.83	8.790	0 307	0.0390	0.979	0.131	0.748	0.1010
January 20.....	10.59	8.114	0.392	0.0420	0.856	0 091	0.727	0.0770
February 24.....	12.32	8.760	0.476	0.0590	1 0400	0.110	0.900	0.1110
Averages.....	13.20	8.53	.....	0.04404	.....	0.113	.....	0.0963

The variations in the ratios are here (See table No. 52) within

rather narrow limits, and a fair degree of correspondence may be detected between ratios and percentages of phosphoric acid, which shows that below a certain minimum difference in ratio the differences in phosphoric acid are not quite so apparent. However, comparing the average ratios and phosphoric acid contents of this tree and the previous one, it is seen that the tree with the higher average ratio has the higher percentage of phosphoric acid.

The potash content shows little variation.

There are fluctuations in the nitrogen. These the writer is inclined to believe that when occurring in one and the same tree are due to difficulties encountered in drying the substance for analysis. In a number of cases the samples were partially charred.

TABLE 53.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No 14, LOCATED AT MR. M. DAVID'S PLANTATION, VEGA BAJA SEASON 1918–1919.

Date on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	16.82	7.370	0.271	0.0456	1.210	0.203	0.469	0.0789
November 26.....	14.58	7.760	0.262	0.0380	0.790	0.115	0.418	.....
January 2.....	14.46	9.290	0.357	0.0471	1.224	0.177	0.172	.....
January 20.....	12.00	7.610	0.409	0.0490	1.428	0.130	0.817	0.0980
February 24.....	8.69	12.080	0.426	0.0370	1.390	0.120	0.862	0.0750
Averages.....	13.31	8.822	.....	0.0433	.....	0.1500	.....	0.0839

No correspondence is here observed between ratios and percentages of phosphoric acid nor is there any regular increase noticed in this item.

The percentage of potash diminished regularly, if the sample picked on November 26th is excepted. It is significant that in every tree the sample picked on this date shows the lowest percentage of potash.

The nitrogen is lower than in the other trees.

TABLE 54.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 15, LOCATED AT MRS. G. D. SMITH'S PLANTATION—SEASON 1918–1919.

Dates on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Orig inal Basis
November 12.....	15.54	7.52	0.284	0.0441	1.240	0.192	0.616	0.0957
November 26.....	12.50	7.83	0.252	0.0320	0.830	0.104	0.660	0.0830
January 2.....	14.06	8.39	0.287	0.0449	1.232	0.173	0.548	0.0710
January 20.....	13.14	9.03	0.362	0.0480	1.107	0.145	0.493	.....
Averages.....	13.81	8.19	.....	0.422	.....	0.151	.....	0.0832

The phosphoric-acid content is here rather constant, if the second sample is excepted. With this notable exception, slight increases have accompanied the increases in ratio. There has been a slight tendency to increase through the season.

The potash has diminished steadily, while the ratio has steadily increased. The only regularity in this respect is presented by the second sample again.

The nitrogen has decreased.

TABLE 55.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 16, LOCATED AT MR. E. R. DAY'S PLANTATION, MANATI.

SEASON 1918–1919.

Dates on which samples were picked	Dry matter	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	17.43	7.86	0.271	0.0472	1.150	0.200	0.566	0.0986
November 26.....	13.80	7.00	0.200	0.0280	0.760	0.105	0.590	0.0810
January 2.....	14.12	7.65	0.297	0.0419	1.1010	0.1550	0.590	0.0833
January 20.....	14.63	7.63	0.342	0 0500	1 0250	0.150	0.556	.....
February 24.....	13.00	9.05	0.382	0.0496	1.290	0.168	0.781	0.102
Averages.....	14 596	7.838	.....	0.0433	.....	0.155	.....	.0905

The phosphoric acid increases toward the end of the season. Again the second sample is abnormally low. Notice that the ratios, except the last and second, which are extremes, lie fairly close together. No regularity is noticeable in the variations.

The potash is rather constant in the last three samples, and lower than in the first. The sample picked on November 26 was once more exceptional.

There are no great differences among the percentages of nitrogen.

TABLE 56.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 17, LOCATED AT MESSRS. SCOVILLE & CASTLE'S PLANTATION, MANATI.

SEASON 1918–1919.

Dates on which samples were picked	Dry matters	Ratio	Phosphoric anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 26.....	14 00	6.23	0.243	0.0340	0.770	0.108	0.674	0.0940
January 2.....	16.30	6.76	0.317	0.0490	.....	.....	0.840	0.1300
January 20.....	16.23	6.03	0.380	0.0620	1.340	0.217	0.772	0.1250
February 24.....	17.91	7.937	0.352	0.0630	1.210	0.2167	0.855	0.1530
Averages.....	16.638	6.575	.....	0.0512	.....	0.1980	.....	0.1255

No matured samples were picked from this tree, except the last, so that it affords an opportunity to observe the change in immature fruit. The last two samples are higher in phosphoric anhydride than either of the first two, while the potash is lowest in the first, and practically constant in the last two. The nitrogen is considerably higher in the last three samples than in the first. Notice that the fruit of this tree, which was green, had higher percentages of nitrogen, phosphoric acid and potash, than that from either of the other trees.

TABLE 57.

Fertilizing Elements in Grapefruit—Whole Fruit.

TREE No. 18, LOCATED AT MR. KACHRLE'S PLANTATION.

SEASONAL VARIATION OF INDIVIDUAL TREES. VEGA ALTA—1918–1919.

Dates in which sample were picked	Dry matter	Ratio of solids to acids	Phosphoric Anhydride		Potash		Nitrogen	
			Dry Basis	Original Basis	Dry Basis	Original Basis	Dry Basis	Original Basis
November 12.....	15.03	7.690	0.284	0 0426	9.270	0.191	.....	.....
November 26.....	12 92	7.430	0.240	0 0310	0.830	0.107	0.682	0.080
January 2.....	12.94	8 596	0.315	0.0407	.....	.....	0.557	0.0720
January 20	15 92	8.576	0.336	0 0534	0.870	0.138	0.358	.....
February 24.....	10.31	9 330	0.392	0.0404	.....	.....	0.569	.....
Averages.....	13.43	8.323	.....	0 0416	.....	0 145	.....	0.080

The sample picked on November 26 shows the lowest content in phosphoric acid and potash. No regular increase or decrease, can be traced in either of the constituents in this table.

From the above tables of individual trees, the following, giving the mean seasonal variation of all the trees tested, was composed:

TABLE 58.

Seasonal Changes in Nutritive Elements in Duncan Grapefruit.

Mean composition of fruit on the dates specified found by averaging the results of the analyses of all samples picked on the same date.

Dates on which samples were picked	Dry matter	Ratio of solids to acid	Phosphoric anhydride P_2O_5	Potash	Nitrogen
November 12	16.196	7.880	0.0441	0.1759	0.0916
November 26	13.496	7.882	0.0331	0.1101	0.0813
January 2.....	13.891	8.838	0.0438	0.1560	0.0860
January 20.....	13.546	8.833	0.0495	0.1338	0.0786
February 24.....	11.126	9.947	0.0495	0.1066	0.0774

All results have been calculated on the whole fruit.

In the above table the phosphoric acid shows a slight tendency to increase, although two irregularities may be noticed on November 26th and January 2nd. Although in a general way the fruit with the higher ratios usually contain higher percentages of phosphoric acid, yet this correspondence does not follow very closely and is only apparent when the differences in ratios are considerable. Thus, although the fruit picked on November 12th had a ratio of 7.88, and that picked on January 2nd had a ratio of 8.838, yet the phosphoric acid of the former is slightly higher than that of the latter. So also the samples picked on January 20th and February 24th had ratios of 8.333 and 9.947 respectively, but their phosphoric-acid contents were the same. However, no sample with a ratio of less than 8 approaches the percentage of phosphoric acid contained by the sample with ratio of 9.947. This item seems to be influenced to a greater extent by the time of picking of the fruit than by the ratio, as may be seen by averaging separately the first three figures and the last three in the foregoing table and comparing the averages obtained.

The gradual descent of the potash as the season advanced is very apparent, the only notable exception occurring in November 26th. For some unaccountable reason all the samples picked on this date, have been uniformly the lowest in the series. In opposition to phosphoric acid, the potash content shows a tendency to be lower in fruits with higher ratios, and in common with phosphoric acid this correspondence is more evident where the difference in ratios is greater.

This statement is supported by data obtained in another experiment, conducted in cooperation with Mr. W. C. Dreier, a very progressive planter of this district. Briefly stated the experiment has consisted in applying potash to a plot, and leaving two plots, one on each side, without any potash for the last five years. A number of observations have been made on the trees and the fruit from these plots, which will be eventually published. For the present purpose, only a series of potash determinations and ratio of solids to acid will be presented here. They follow in tabular form:

Potash in Grapefruit.

DUNCAN VARIETY.

Number of sample	Date fruit was picked	Plot A		Plot B		Plot C	
		Ratio of solids to acid	Per cent potash	Ratio of solids to acid	Per cent potash	Ratio of solids to acid	Per cent potash
1	June 13, 1919	.....	0.207	.....	0.2310	.....	.....
2	October, 1919	5.98	0.205	5.87	0.2190	8.00	0.1770
3	January 31, 1920	9.00	0.151	7.50	0.196	4.97	0.2496
4	February 24, 1920	10.26	0.1077	8.40	0.1427	7.00	0.1110
5	March 29, 1920	9.60	0.168	10.50	0.1641	8.00	0.1778
6	May 17, 1920	9.30	0.116	8.00	0.1303	10.00	0.1240
	Averages		0.1591		0.1805		.1678

Plots A and C received no potash. Plot B received potash.

In this table notice that the most unripe fruit contains the highest percentage of potash in each lot, and that with few exceptions the fruit with the higher ratios contain less potash. Again the descent in potash is more apparent where the differences in ratios are greater.

Incidentally it may be noticed that the fruit from the plot which received potash shows up a little more potash than that from the plots receiving no potash. However, the difference is very small.

The nitrogen content of the fruit does not seem to be affected by the time of picking of the fruit although it might be remarked that the last two sets of samples picked showed the lowest averages. There is no well-established relation between nitrogen content and ratio of the fruit except that the tree from which only immature fruit was obtained, with a ratio of 6.575, showed the highest nitrogen content of all.

As regards dry matter in the fruit, it must be borne in mind that these figures represent the dried residue resulting from drying the chopped fresh fruit in a big air oven where uniformity of temperature was hard to attain, and therefore are scarcely comparable. However, they show such a regular gradual fall through the season, that some value may be attached to them. They show evidently that the fruit kept gaining in juice all through the season, and that in a general way the fruit with the higher ratio contained a higher percentage of juice, and softer tissues.

COMPARISON OF TREES.

The composition of the fruit from the different trees showed a fair degree of uniformity as evidenced by the following:

TABLE 59.

Fertilizing Elements in Grapefruit—Whole Fruit.

Averages of each tree for the whole season.

DUNCAN—1918–1919.

Tree number	Dry Matter	Ratio	Phosphoric acid, original basis	Potash, original basis	Nitrogen, original basis
12	14.10	9.459	0.0489	0.1368	0.1036
13	12.20	8.530	0.0440	0.1180	0.0965
14	13.31	8.822	0.0433	0.1500	0.0839
15	13.81	8.190	0.0422	0.1510	0.0832
16	14.59	7.839	0.0433	0.1550	0.0905
17*	16.64	6.575	0.0512	0.1980	0.1255
18	13.43	8.220	0.0413	0.1455	0.080
Averages	14.15	8.247	0.0449	0.1518	0.0896

[1] Tree No. 17 was left out of the averages, as the fruit picked from it was all green fruit.

The only notable exception is tree No. 17, from which, as explained, all samples picked were immature. This tree, therefore, should not be compared with the rest, from which ripe, matured fruit was always obtained. Desregarding this one tree, then, we find a fairly close agreement in the percentages of phosphoric acid, potash, and even nitrogen. Only two exceptions are worth noticing, and those are the percentage of potash in the fruit from tree No. 13 and the percentage of nitrogen in the fruit from tree No. 12. The dry matter is also in close agreement.

Comparing now the green fruit from tree No. 17 with the rest, we find a ratio much lower than any of the others accompanied by notable higher percentages in all the constituents determined as well as in dry matter. This suggests a lower content of juice in the greener fruit, and lends evidence to the assumption that most of the mineral constituents of the fruit, if not all, are absorbed and incorporated in the fruit in the earlier stages of development, and that the latter part of the development until maturity is reached is taken up chiefly by an absorption of water and changes in the combinations of the elements already absorbed.

The changes noticed are not wide enough, nor regular enough, to justify any further conclusion as to the variations in the plant constituents of the fruit during the process of maturation. A greater number of analyses, and a more extended period of observation are required before any definite facts may be ascertained. It seems safe, however, to assume that after the fruit is developed

very little changes, if any, occur in its mineral composition or its nitrogen content. Perhaps the only ingredient suggesting a regular variation is the potash.

Although the kind of soil and the fertilizer differed for each one of the trees tested, yet the percentages of the different ingredients found for each tree (excepting tree No. 17) agree fairly well. This seems to indicate that these two factors do not affect very prominently the chemical composition of the fruit. As to the effect of soil, we will see further on. As to the effect of fertilizers, we have not enough data of our own. In the paper entitled "Effect of Fertilizers on Oranges" by H. D. Young of the California Experiment Station, which appeared in the *Journal of Agricultural Research*, Vol. VIII No. 4, pages 127–138, the conclusion is expressed that—

"There was no increase in the amount of either phosphate or potash in the fruit brought about by the quantities applied in this experiment."

To further quote from this interesting paper we may copy the following sentence:

"The averages from these plots receiving fertilizers are almost identical with those not fertilized."

Our figures, so far as we have gone, are in accord with these conclusions.

SUMMARY OF PART I.

The whole discussion that precedes may be summarized thus:

1. The changes that take place in the fruit during its development, viz., increase in juice content, increase in weight, decrease in the proportion and thickness of the skin, etc., become less and less perceptible, until finally they cease to be perceptible, as maturity approaches.

2. Obvious signs of maturity, such as color of the fruit, condition of the juice cells, taste of the juice, and general appearance, coincide with cessation in the increase of weight and juice, and the decrease in the content of skin, as well as with the decrease in acid content and the increase of ratio of solids to acids; also with the end of the process of sugar elaboration and the beginning of inversion of sucrose.

3. Taking the changes enumerated and the signs of maturity above referred to as criteria to judge the maturity of the fruit, it may be assumed that grapefruit here may not be considered ripe

and fit to eat before the ratio of solids to acids in solution in the juice has reached at least 7. This minimum ratio should be accompanied by the signs of maturity evident on inspection.

4. The changes enumerated above apply in a general sense to the three varieties tested, but the rate at which they proceed and the extent to which they take place differ for each variety. The details of this comparison have been given on page—.

5. The "Duncan" and the "Marsh's Seedless" varieties attain the legal ratio of 7, and ripeness toward the end of the month of November. The "Triumph" variety shows the legal ratio very early in the season, before September, but true maturity is not probably reached until November.

6. The sugars are formed toward the latter part of the development of the fruit, and their elaboration ceases when maturity is attained. After maturity the sucrose suffers inversion, and some decomposition of invert sugar takes place.

7. All of the solids, acids included, except the sugars are formed at a very early stage in the development of the fruit. When the fruit is yet very green, the percentages of solids in solution, and the ratio of solids to acids are very high. With further development of the fruit the percentages of solids and the ratio descend. When the process of maturation begins the ratio increases regularly again, due to a gradual decrease in the acid content until perfect maturity is attained.

8. The fact that the nutritive ingredients in the fruit, viz., nitrogen, phosphoric acid and potash, are in a higher proportion in the green fruit than in ripe or nearly ripe fruit, further confirms the conclusion that practically all of the solids are formed in the earlier stages of development of the fruit.

9. With fruit which is fully developed no regular changes in the content of nutritive ingredients of the fruit could be detected during the seasons. There are indications, however, that the phosphoric acid may be higher and the potash lower in ripe than in unripe fruit.

10. The proportion of nitrogen, phosphoric acid, and potash were rather uniform for the different trees, a fact which suggests that neither the kind of soil nor the kind of fertilizer have much influence on these items, especially the last two. More work is necessary along this line.

[END OF PART I.]

Part II of this work will appear in a subsequent issue of this JOURNAL.

PUBLICATIONS OF THE YEAR (1920–1921).

(PUBLISHED OR IN PRESS.)

Circular No. 26.—Antrax, por Jaime Bagué.

Circular No. 27.—Restricciones Legales al Comercio de Plantas en Puerto Rico, por M. A. Crespo y L. A. Catoni.

Circular No. 28.—The Cultivation of Citrus Fruits in Porto Rico, by F. S. Earle.

Circular No. 29.—La Morriña Negra, por J. Bagué.

Circular No. 30.—El Mejoramiento de Nuestras Siembras por la Selección, por E. E. Barker.

Circular No. 31.—La Renovación del Terreno por Medio de Siembras Intermediarias de Plantas Leguminosas par E. E. Barker.

Circular No. 32.—La Enfermedad de la Raíz en el Café, por J. Matz.

Circular No. 33.—Varios Trabajos (Presentados en la Reunión de Productores y Profesionales Azucareros celebrada en Río Piedras el 17 de noviembre de 1920).

Circular No. 34.—La Vaquita o "Piche" de la Batata, por J. D. More.

Circular No. 35.—El Cultivo del Cocotero en Puerto Rico, por P. González.

Circular No. 42.—El Muermo, por J. Bagué.

Bulletin No. 24.—Citrus and Pineapple Fruit Rots, by J. Matz.

Boletín No. 26.—Abonos, por R. Vilá Mayo.

Bulletin No. 27.—Plant Inspection and Quarantine Report (1919–20), by L. A. Catoni.

The Journal of the Department of Agriculture, Vol. IV, No. 3.—An Annotated List of Sugar Cane Varieties, by F. S. Earle.

Annual Report of the Insular Experiment Station of the Department of Agriculture and Labor, for the year 1919–1920.

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